ELECTRICAL ENGINEERING

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MAY 1958
Vol. 77, No. 5

Published monthly by American Institute of Electrical Engineers

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Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
Founded 1884

Headquarters, 10th floor • Editorial Offices, 6th floor
33 West 39th Street, New York 18, N. Y.

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ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office Hildreth Press, Bristol, Conn. Editorial and advertising offices 33 West 39th Street, New York 18, N. Y. Member subscription $6 per year nondeductible from dues: single copy 75 cents. Nonmember subscription $12 per year plus extra postage to all countries to which second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Bristol, Conn., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. May 1958. Vol. 77, No. 5. Number of copies this issue, 67,500.

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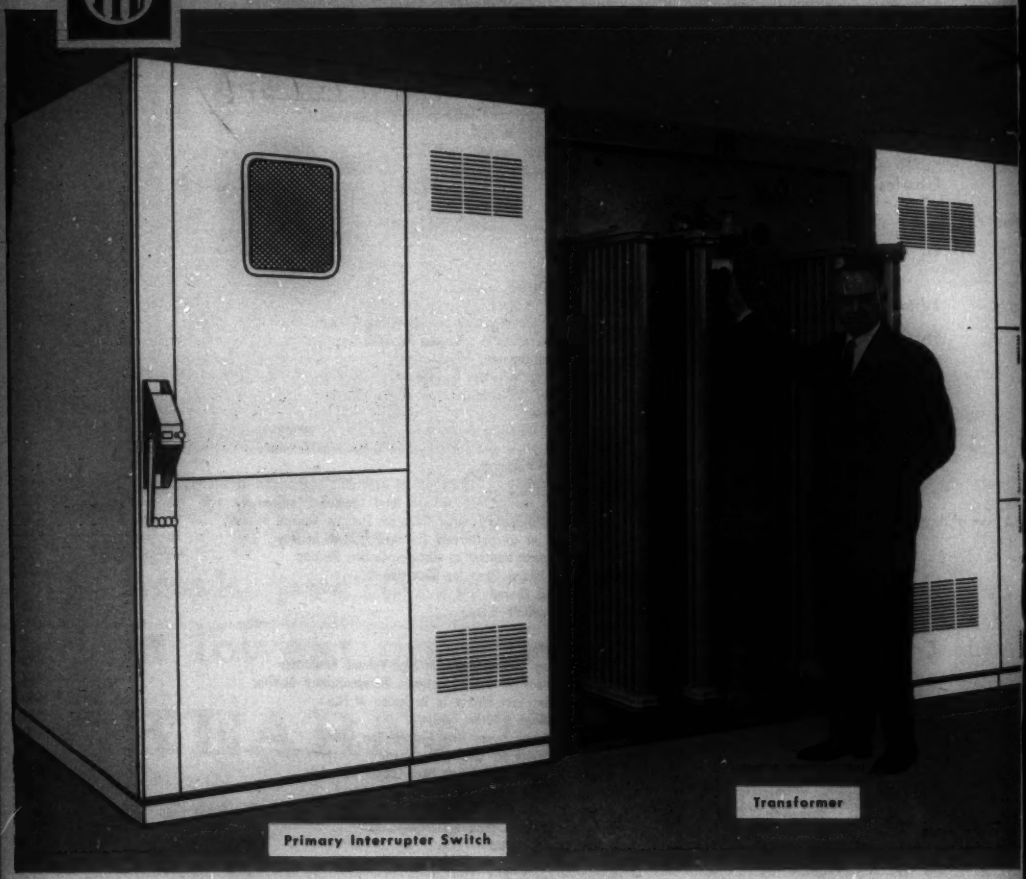

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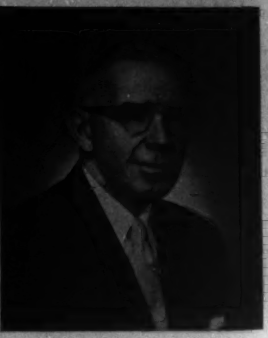

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WALTER J. BARRETT
PRESIDENT

Dear fellow member of AIEE:

Real progress is being made toward the realization of our plans for the new United Engineering Center. This new headquarters for the engineering profession of the country will occupy an entire block front on United Nations Plaza in New York City. It will house the five Founder Societies, namely:

American Institute of Electrical Engineers
American Society of Civil Engineers
American Institute of Mining, Metallurgical and Petroleum Engineers
The American Society of Mechanical Engineers
American Institute of Chemical Engineers

as well as a number of other national engineering societies. The prestige of the new location and the beauty of the new building will be in keeping with the dignity of a proud profession.

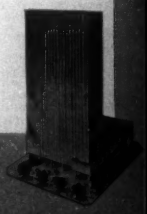
Each of the societies co-operating in this project through United Engineering Trustees, Inc., is preparing a campaign to invite all of its members to make individual contributions to the cost of the building. Of the more than $10 million total cost of the project, the goal of the AIEE member-giving campaign is $900,000 to be collected between now and the end of 1960. We are indeed fortunate in having Dr. Lester M. Goldsmith of Philadelphia as our Campaign Chairman. He is already working with our District Vice-Presidents and Section Chairmen on plans and organization.

The plan of our Campaign Committee contemplates that every individual member of AIEE will be approached directly by a solicitor, one of your fellow members who will be giving of his time and energy for the campaign. We are all accustomed to making annual contributions to a number of worthy causes. This, however, is a once-in-a-lifetime opportunity to take part in the greatest project ever undertaken by the organized engineering profession, and a project which by its very nature is bound to be the most constructive step yet taken in the direction of real unity in the profession.

I know that when a member of the Campaign Committee calls upon you, you will pledge a contribution commensurate with your means.

Cordially,

President-AIEE
President-UET Inc.



Electrical Engineering Education and Research in the USSR

P. A. ABETTI
MEMBER AIEE

G. F. LINCKS
FELLOW AIEE

First part of a two-part article on education and research in the USSR. Based on Lenin's conviction that "you cannot build a Communist State with illiterate people," the Soviet Union has, since Tsarist days, made a tremendous effort to build up a pool of professional and technical manpower to "catch up" with and then surpass the capitalistic countries.

Part I—Education

THE CHILD in the Union of Soviet Socialist Republics (USSR) starts his or her required formal education in the elementry school at the age of seven and continues until he or she is 14, as shown in Fig. 1. They go to school five hours a day from early September until about the middle of June. This schedule continues up through Middle School and is not very much different in the universities.* The teaching of foreign languages starts at an early age, as is common in Europe. Of this school time, 30% is spent on the sciences up to the age of 11 and 40% thereafter through middle schools regardless of whether the students are to dig ditches or become scientists.

Upon graduation there are four possibilities:

1. To go into industry or agriculture
2. To enter a factory school
3. To enter a "Technicum" for training as technicians for industry, agriculture, teaching, physical education, etc. (Somewhat similar to our technical high schools)
4. To enter the middle school, ages 14 through 17 (similar to the college preparatory courses in our high schools)

All through the school period, the pupil is subjected to teachings in the ideology of the Communist Party. Not very much classroom time is spent in the elementary and middle schools. It is done largely in the youth organizations—the Little Octoberists, ages 8–11, the Pioneers, ages 9 to 14, and the Communist Youth, ages 14 to 25. There is some overlapping of ages to provide leadership and continuity. There is direct teaching of communist ideology in the universities, as will be discussed later.

UNDERGRADUATE TRAINING

General Statistics. According to the latest available figures,[6] higher education in the Soviet Union takes place in 33 universities and 758 institutes or higher technical educational establishments, which will all be designated as "institutes" from now on. All engineering training takes place in 177 engineering-industrial institutes (23% of the 758). Of these 177 engineering–industrial institutes, there are 24 (14%) polytechnical and industrial, for engineering training in various fields, including electrical engineering; 8 (4%) electrical engineering (including electronics) and engineering physics; 9 (5%) chemical engineering; 27 (15%) civil engineering.

DeWitt estimates that 12 to 14% of the 321,400 engineering students enrolled in 1950 in the Soviet institutes were in the field of electrical and power engineering. As a comparison, in 1953 about 20% of the 171,000 engineering students in the United States, were in the electrical engineering field. There are at present 71,000 graduates a year from the engineering institutes in all parts of the USSR. Using the relative percentages of 1950, about 9,100 electrical engineers are presently graduating each year in the USSR, of which about 30% are women. The latest available[12] American figures are 27,500 engineers in total and 6,600 electrical engineers graduating in 1955-56, with a negligible percentage of women. It may be concluded that in the USSR, the graduates per year in engineering as a whole are about 2½ times as many as in the United States, while electrical engineers are about 40% more.

Organization and Specialization. Engineering institutes come under the Ministry of Higher Education. Each institute is subdivided into from 3 to 8 divisions (fakul'tety) depending upon the size and scope of the institute. In turn, each division is divided into specialties or majors (spetsial'nost), which are usually further subdivided into specializations (spetsializatsiya), as shown in Fig. 2. However, there seems to be no specialization in the high voltage engineering major.

This characteristic of extreme specialization is typical of the Soviet system for engineering and other technical training, and should be considered with respect to its

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y. Feb. 2-7, 1958. Recommended for publication by the Educational Publications Committee.

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* One of the authors was in attendance at the International Electrotechnical Commission meeting in Moscow, USSR, June 30 to July 13, 1957, with more than 400 engineers from 27 countries. He visited electrical installations, research institutes, and educational engineering institutes in Moscow and Leningrad. He acquired several books and pamphlets[1-5] concerning electrical engineering curricula and research institutes. In addition to this personal contact, the authors have studied available publications on Soviet electrical engineering education and research.[6-23]

immediate benefits and possible long-range consequences.

Admission Requirements. The entrance requirements for engineering institutes are (1) the certificate of having been a gold star pupil (90-100%) in middle school (less than 10% of those accepted) or, more commonly, (2) written entrance examinations in the Russian language and literature, one foreign language (English, French, or German), physics, mathematics, chemistry. The written examinations last about 2 hours for each subject, the oral examinations about 15 to 20 minutes. There is no oral examination in Russian language and literature.

The competition is quite high because there may be anywhere from 2 to 7 or more applicants for each vacancy, the higher figures usually being for electronics majors. The student chooses his specialization with some knowledge of the available opportunities determined by the Ministry which will eventually employ him. If there are no opportunities, the student is given other choices of specialization toward which to direct his or her efforts.

Tuition and Stipend. Tuition is either free or very low, from 300 to 800 rubles per academic year. This can be evaluated best as about ⅛ to one month's starting pay after graduation per academic year, whereas in the United States tuition and board runs at about 6 to 7 months starting pay per academic year, as shown in Fig. 3.

In addition, students receive a grant, called "stipend" from 300 to 600 rubles a month, which increases from the first to the last year of study. This stipend is paid only if the student receives passing grades, and a 25% bonus is given for grades above 90 up through 100. If grades are below passing, the stipend is discontinued but the student may be permitted to repeat the course. The stipend evidently varies from institute to institute and for the degree of hardness or attractiveness of the major. For outstanding students it may be as high as 1,000 rubles per month. Furthermore, there are available special Stalin prizes of 800 rubles each. For comparison, room and board at Moscow University amounts to about 300 to 350 rubles per month. It is estimated that at least 75% of the students enrolled receive stipends. A powerful incentive for electrical engineering students is the exemption from military service, which is either omitted completely or performed for short periods.

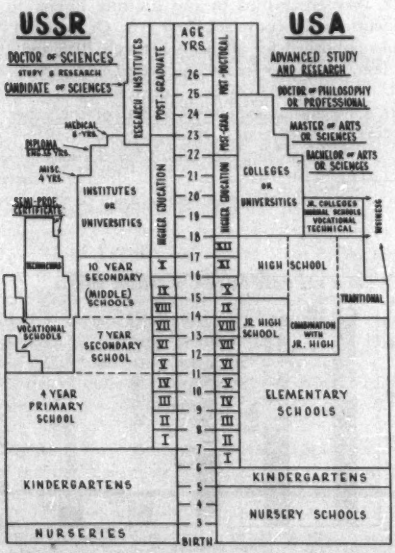

Fig. 1. Comparison of educational systems in the USSR and the United States.

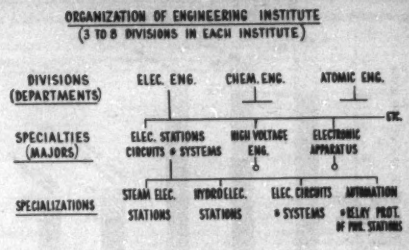

Fig. 2. The organization of institutes.

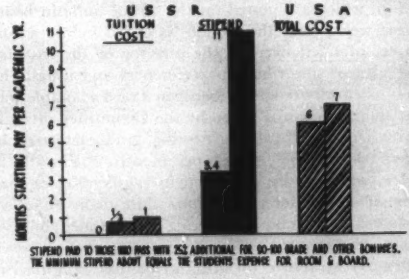

Fig. 3. Tuition and living expenses.

Placement. Most of the students entering an engineering institute eventually graduate. It is stated that attrition is about 5% the first year, and 3% in each of the following four years.[6] Thus, about 82% of the students admitted to the institute graduate. Other sources state that this figure is only 70%.[7] In comparison, only 57% of the students admitted to engineering colleges in the United States graduate, on the average.[10]

The government employs all graduating students except a few foreigners. About four months before the end of the course, the graduating student examines notices of vacancies in various positions in his special-

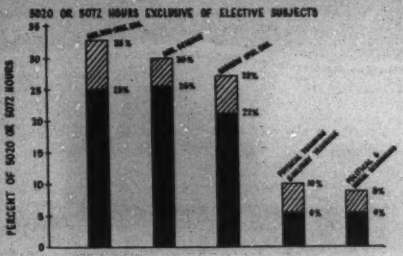

Fig. 4. Allocation of time by major fields of study.

ization, which are posted on the school bulletin board. A few weeks later the student is called before a committee, presided over by the director of the institute. The student states his job preferences and usually has the opportunity to choose between 2 or 3 available jobs. The final decision is made by the Committee. Starting salaries for electrical engineering graduates vary between 800 to 1,500 rubles per month. Practically all Soviet graduates are employed in engineering or management work after graduation, while many American graduates enter non-engineering fields (sales, business administration, etc.).

General Structure of the Curriculum. Engineering courses last 5½ years or 233 weeks of work, plus 53 weeks of vacation. This time may be divided into four parts (Fig. 1)—(1) Classroom lectures and practice; (2) Examinations: 33 weeks (14%); (3) Industrial Practice: 19 weeks (8%); and (4) Thesis or diploma project (diplomnyi proekt): 24 weeks (10%).

Excluding the thesis and industrial practice, the total hours of instruction are between 5,000 and 5,500. The 1,000 to 1,100 hours in the 5th year are concentrated wholly on the student's specialization which is only possible in a country like the USSR, where everyone works for the government and the availability of positions is known in advance. For comparison, the engineering curriculum for B.S. degree in the United States comprises in total 3,000 hours or less. However, the American graduate specializes in one phase of his major after he enters industry rather than in a 5th year at college.

Allocation of time by major fields of study[6] and by learning procedure are shown in Figs. 4 and 5 respectively.

Nontechnical subjects are concentrated largely in the first and second years and consist principally of ideology of communism and physical training or military instruction. Except for languages, there are no liberal art subjects in the curriculum. The number of subjects of instruction depend upon the specialty and vary between 30 to 45, as compared with 20 in the United States, if grouped the same way.

The same subjects are studied by all students during the first year. In the second, third and fourth years, the subjects studied are the same for all students in a given major and in the fifth year differ according to the specialization selected. Within the general sciences, mathematics gets 300 to 400 hours total and physics 200 to 400 hours total.

Grades and Examinations. In order to graduate, the student must have passing grades or higher in all instruction subjects included in the curriculum. There are four grades: excellent, denoted E or 5, 90–100/100 which leads to graduation with distinction; good or 4 (80-90/100); passing or 3; and "bad" *(plokho)* or 2, nonpassing. During any academic year a student may not carry nonpassing grades in more than two or three subjects. He may repeat examinations several times during the year to try to get a passing grade. However, if by the end of the year he has not passed, he is dismissed or, under rare circumstances, can repeat the entire year.

Grades are based upon both the work done during the school term and the final examinations. Term grades may be based on homework assignments, course projects, laboratory work, and written examinations during the course. If the term grades are not satisfactory, the student is not permitted to take the final examination.

Final examinations are either oral or written, but in most courses only oral. Written examinations last about 2 hours and comprise 2 or 3 questions which are the same for all participating. Oral examinations comprise several questions printed on cards, which are drawn at random by the examinee.

Textbooks. Textbooks are prepared by the institute and then approved and printed by the ministry. As a rule, they are loaned by the institute library to the students for the entire academic year. Of the 2,864 textbooks published for all fields between 1938 and 1948, no less than 1,233 (or 40%) covered engineering subjects. Of these, 133 covered electrical engineering subjects. One author examined several of the latter, including two textbooks on high-voltage engineering. These are quite complete—full of lengthy technological discussions with charts, drawings, diagrams, covering everything to the minutest detail. Much of the informa-

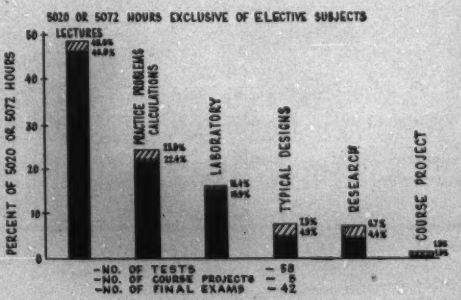

Fig. 5. Allocation of time by learning procedure.

tion, including entire tables, charts, and illustrations, was copied directly from earlier American and German publications. In some cases, the original sources were quoted, in others not at all. In some cases textbooks of foreign authors have been translated completely; for instance, Bewley's well-known book on traveling waves.[14]

The general impression given by the Russian textbooks is again specialization and attention to details; for instance, standardization features, rather than to fundamentals and philosophy of the discipline. Probably, these textbooks are used later by the engineers as manuals for standards, design, and operating rules in their practical work.

THE MOSCOW POWER INSTITUTE

THE BEST KNOWN Russian electrical engineering institute was visited by one of the authors—the "Moscow Power Institute" also referred to as the "Moscow Electro-Energetic Institute." This is one of the three Russian institutes which train engineers for the electric power industry (the other two are in Leningrad and Ivanov).

The Institute, founded in 1905, has 12,500 day students from 17 to 35 years of age, and 2,000 evening students. Two thirds of the students are electrical engineers and 30% are women. In 1956, it graduated 1,260 electrical engineers. The teaching staff comprises 1,030 persons; 76 are full professors, and the remainder assistants, instructors, and postgraduates. There are, in addition, 600 training masters in the laboratories and 1,400 other personnel. Thus, the ratio of students to teachers is approximately 14 to 1. For electrical engineering schools in the United States this ratio ranges from approximately the same to 30 or 35 to 1.

Organization. The Institute has nine day divisions and one evening division. Most of the day divisions, as we have seen, are divided into specialties and these, in turn, may be divided into specializations (Table I). A title for each specialty is conferred in the diploma received by the student upon completion of the undergraduate studies. There are in total 40 possible specializations for day students and 9 for the evening students.

Each division has its own special laboratories. For instance, the Electric Power Division has the following: (1) electric stations, (2) relay protection and automation of power systems, (3) circuits and systems, (4) high-voltage engineering; and (5) the Electro-Vacuum Engineering and Apparatus Construction Division has — (a) foundations of radio engineering, (b) radio transmitters, (c) radio receivers, (d) antennas, and (e) radio measurements.

In addition, there are other general laboratories and offices (kabinety) used by students of all divisions for practice assignments, such as general physics, fundamentals of electrical engineering, general electrical engineering, strength of materials, drawing, etc. The institute library has 600,000 volumes in Russian and other languages.

Table I. List of Day Division's Specialties and Specializations at the Moscow Power Institute[a]

Division	Specialty	Specializations
Electric Power (Title*: Electrical Engineer)	Electric Stations Circuits and Systems	Thermoelectric Stations Hydroelectric Stations Electric Circuits and Systems Automation and Relay Protection of Power Systems
	High-Voltage Engineering	
Thermal Power (Title: Thermal Power Engineer or Thermo-Physicist)	Thermal Power Equipment of Electric Stations	Turbine Equipment Boiler Equipment Automation of Thermal Power Equipment Thermoelectric Stations and Thermal Systems
	Water and Fuel Engineering for Electric Stations and Industrial Installations	
	Thermophysics (Atomic Power Stations)	
Industrial Thermal Power (Title: Thermal Power Engineer)	Industrial Thermal Power	Heat Supply and Thermal Power of Factories Industrial Furnaces Industrial Gas Supply Industrial Desiccating Equipment Industrial Heat Exchanger Equipment Automation of Industrial Thermal Processes
Hydraulic Power (Title: Hydraulic Power or Hydraulic Construction and Operation Engineer)	Hydraulic Power Equipment	
	Hydraulic Construction of Fluvial Installations and of Electric Stations	
Power Machinery Construction (Title: Mechanical Engineer)	Turbine Construction	Steam Turbines Gas Turbines
	Boiler Construction	
	Hydraulic Turbines and Other Hydraulic Machines	
Electro-Mechanical (Title: Electro-Mechanical Engineer)	Electric Machines and Apparatus	Electric Machines Electric Apparatus
	Electric Insulation and Cables	Cable Engineering Electric Insulating Materials and Structures Capacitors
	Dielectric and Semi-Conductors	
Electrification of Industry and Transportation (Title: Electro-Mechanical Engineer)	Electrification of Industrial Concerns and Plants	
	Electrothermic Plants	
	Electrical Transportation and Urban Electrical Transportation	
Electro-Vacuum Engineering and Special Apparatus Construction (Title: Electrical Engineer)	Automatic, Telemechanical and Electric Measuring Apparatus and Devices	Automation and Telemechanics Electric Measuring Apparatus
	Mathematical and Computing Apparatus and Devices	
	Electronic Apparatus	
	Industrial Electronics	
	Illumination Engineering and Construction of Projectors	
Radio Engineering (Title: Radio Engineer)	Radio Engineering	
	Construction and Manufacturing of Radio Apparatus	

* *This is the official title on the diploma conferred upon completion of undergraduate training.*

medical, and engineering fields; the remaining 25% in the humanities, arts, and social sciences; with about 3,400 candidate degrees (40%) and 150 doctor degrees (21%) in engineering.

However, only a minority of the persons receiving doctor's degrees had previously earned a candidate degree. While the proportion of women completing undergraduate training is about 50% (30% in electrical engineering), 20% receive candidate, and 5% a doctor's degree.

For comparison, of the about 3,600 M.S. degrees or equivalent 1,560 doctor degrees granted in the same year in the United States, only about 23% were in the fields of science, medicine, or engineering. This comparison shows the tremendous importance of advanced training in science and engineering in the USSR, a unique phenomenon which has no counterpart in any country. (Part II will cover Research in the USSR.)

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THE ENGINEERING FOUNDATION

Its Aims and Activities

E. I. GREEN
FELLOW AIEE

The Engineering Foundation's Board of Directors is anxious to make its activities better known and understood. Greater participation by AIEE is sought.

FOUNDATIONS, or in other words philanthropic endowments, are not new; indeed, they are of ancient invention. More than a thousand years before Christ, the Pharaohs set up perpetuities for certain religious ceremonies. In the 5th Century B.C., Cimon of Athens established a public park, known as the Garden of Academus. Here Socrates delivered his orations, and here Plato established and endowed his school, which became known as the Academy and survived for almost 900 years. Thus, down through the ages, countless foundations have sought to promote man's welfare in one way or another.

AMERICAN FOUNDATIONS

IT REMAINED, however, for accumulating wealth, coupled with a sense of the fitness of humanitarianism in a democracy, to bring endowed philanthropy to its fullest flower in the United States. An early bellwether was the bequest by Benjamin Franklin in 1790 of £1,000 each to Boston and Philadelphia, these funds to be used for loans (loans at interest, as might be guessed from the well-known traits of the donor) "to young, married artificers of good character." Parts of these two funds have been used for the Franklin Institute and the Franklin Union.

Today foundations are found everywhere. They are a great and growing phenomenon of the American scene. They minister to our health and happiness; they further our education; they analyze our behavior; they advise our Government; they cultivate arts and artists; and they waft music to our ears. There are foundations for animals and for birds. In Olathe, Kans., a trust fund provides Christmas dinners for horses. A fund in Mashpee, Mass., is supposed to reward local boys for "good, kind manners," but it is reported that the administrators have had difficulty because they could not "find enough mannerly boys to reward."

The 7th edition of Wilmer S. Rich's reference book on American Foundations lists a total of 4,162 founda-

Special article based on a speech made at a session sponsored by the AIEE Research, Education, and Insulated Conductors Committees at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958.

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tions in the United States. Counting all those for which information was not available, and those which did not meet the qualifications laid down by the publisher, the actual number probably is twice as many. In order to be listed, the "foundation" must be a nonprofit legal entity provided with funds intended to serve the welfare of mankind. The legal entity does not have to be called a foundation; it may be a fund, trust, endowment, corporation, association, society, or what not.

Alongside such foundations as Ford, with its $493 million; or Rockefeller, with $447 million; the Engineering Foundation's (EF) capital fund of $1,570,191.08 looks rather small. Perspective is regained, however, by observing that, out of the 4,000 some odd total, fewer than 1,000 foundations are larger than EF.

Among the foundations listed, Engineering Foundation is one of the more venerable. Only about 50 now on the list were in existence when EF came into being more than 40 years ago.

In listing their fields of interest, 37 of the more than 4,000 foundations mention engineering. For all of these except Engineering Foundation, however, engineering is but one of a number of fields of interest. Thus, engineering is found bracketed with democracy, citizenship, education, economics, social welfare, babies, children, youth, old folks, religion, aesthetics, recreation, and so on. Only EF is concerned primarily with engineering.

ORGANIZATION OF ENGINEERING FOUNDATION

THE ENGINEERING FOUNDATION was originated in the year 1914 when an unnamed person, later identified as Ambrose Swasey, a mechanical engineer of Cleveland, Ohio, indicated his desire to make a "gift to engineering in general, and for the conduct of research in particular." Clearly, a desire like this ought to be gratified. Accordingly, an endowment fund designated as the Engineering Foundation Fund was set up under the administration of the four major engineering societies—AIEE, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), American Society of Civil Engineers (ASCE), and the American Society of Mechanical Engineers (ASME). Mr. Swasey's gifts, which totalled over $800,000, were augmented by other contributors, the grand total to date being, as noted, a little over $1.5 million. A large recent addition, received in 1956, was a bequest of $400,000 from the estate of Edwin H. McHenry. Incidentally, no bequest or donation, whatever its size, is refused by the Foundation.

Organizationally, the Engineering Foundation is a department of United Engineering Trustees (UET). Under the charter, UET acts as custodian of the endowment fund and turns the income over to the Foundation Board for disposal. The Board membership is drawn largely, if not entirely, from the four constituent societies.

In prescribing how the Foundation funds are to be used, the wording of the charter is admirably broad. The Board is empowered to "use any part of its resources in any manner which it deems proper, for the furtherance of research in science and engineering, and for the advancement in any other manner of the profession of engineering and the good of mankind." Likewise the Board "may make known to the world the results of its undertakings by publication, by public lectures, or by other means, in its discretion."

ACTIVITIES OF ENGINEERING FOUNDATION

OVER THE YEARS, Engineering Foundation has given upwards of a million dollars in financial support to more than 125 different projects. Because of its relatively modest resources, the Foundation Board in apportioning its funds has employed to a considerable extent the so-called "seed money" technique. That is to say, it has preferred, where practicable, to make its grants contingent upon the raising of considerably larger amounts from other sources. The sponsorship and financial assistance of EF in the early stages of a project frequently serve to carry it to the point where adequate support can be derived from other sources. Thereafter, a "token grant" evidencing Foundation approval is deemed sufficient. As a result of this philosophy, EF's million dollar contribution to projects has been accompanied by more than $10 million from industrial and other sources. To what extent the grants of the Engineering Foundation may have caused or influenced these other contributions no one can say. Those who have been close to the situation believe that EF has been a large motivating factor.

In fulfillment of its commission to further engineering research, Engineering Foundation has sponsored and supported many notable advances. Subjects dealt with by completed or current projects include such things as fatigue and diffusion in metals, properties of concrete, arch dams, soil mechanics, structural foundations, columns, riveted and bolted structures, waves and shore erosion, storm surges, properties of steam and gases, lubrication, and heat transfer in fluids. Finally, there is one called comminution, i.e. pulverizing. The work of many Foundation-supported projects—the Welding Research Council and the Alloys of Iron Research, is known and utilized throughout the world.

About one fourth of the Engineering Foundation's projects are of the "research council" type. These are cooperative projects which are organized, with the aid of EF, by a group of engineers in one or more of the constituent societies to carry out a program of research in some particular domain of engineering. Each council serves to co-ordinate a number of research activities under the supervision of various committees. Normally, annual or semiannual council meetings are held, at which reports are presented, new projects initiated, etc. Foundation-organized-and-supported research councils now in existence, some of a good many years' standing, are: Column Research Council, Research Council on Riveted Bolts and Joints, Reinforced Concrete Research Council, Alloys of Iron Research, Corrosion Research Council, Welding Research Council, and Council on Wave Research.

In addition to its contributions to engineering re-

search, EF has done much to advance the engineering profession as a whole. Thus, it has underwritten the preparation and publication of several important textbooks. It has financed studies of engineering aptitudes, engineering education, and the like. It assisted in bringing the Engineers' Council for Professional Development (ECPD) into being in 1932, and it has made substantial annual contributions to ECPD ever since. Probably, the best-known activity of ECPD is its work in accrediting engineering curricula, a task of great importance and equal if not greater difficulty.

The Foundation Board is fully cognizant of the latitude afforded by its charter to foster any sort of activity for the good of mankind. In view of its limited funds, however, the Board thus far has tended to shy away from the diffusion of its efforts that this would seem to imply. It has chosen, instead, to concentrate on the field of engineering, and believes that its activities in this field do indeed contribute to the good of mankind. Any appropriately modest but uniquely challenging proposal for a nonengineering project for the benefit of mankind would certainly receive thoughtful attention.

Until fairly recently, the Board has had at its disposal an annual amount of about $65,000. With the McHenry bequest and other additions, this amount will shortly go up to approximately $100,000.

An analysis of grants for fiscal 1957-58 shows:

Projects	Number	Total Grants
Research Council	9 (2 special)	$22,500
Co-operative research (EF and industry)	16	38,000
Research supported solely by EF or receiving university help	6	16,500
ECPD	1	3,000
	32	$80,000

Of the current Engineering Foundation projects, 12 were recommended by AIME; 6 by ASCE; 10 by ASME; and only 2, namely, Wood Pole Research and Thermal Resistivity of Soils, by AIEE. In fact, there was a considerable period when there were no AIEE sponsored projects. The Board would be happy to consider any new projects that AIEE might recommend.

PROCEDURES

THE PRESENT PRACTICE of Engineering Foundation is to initiate no projects itself. It merely selects, from applications received, those projects that seem most deserving of support. Many Foundation projects originate in the research committees of the constituent societies. Other applications that come direct to EF are, whenever appropriate, submitted to one of the research committees for cognizance and recommendation.

Applications for grants during the fiscal year, which begins October 1, should be sent to the Director of Engineering Foundation by February 15. The applications are reviewed by the Foundation's Research Procedure Committee, and acted upon by the Board at its annual meeting early in May.

FUTURE PROGRAM

SO MUCH for present activities and procedures. There can be little dispute that Engineering Foundation has done and is doing a very commendable job. In this kaleidoscopic age, however, established practices are always fair game for questioning. Fast-moving technology should create new challenges and opportunities for the Foundation. Mindful of this, the chairman appointed a Planning Committee some time ago to consider what changes, if any, should be made in the present program. Until now, this committee has come up with no final recommendations. Suggestions from any quarter are distinctly in order.

In setting bounds to its activities, Engineering Foundation, in the past, has avoided three fields: (1) military research, (2) materials and products research, and (3) basic research. The feeling has been that these admittedly important fields can better be left to other agencies, specifically to Government, industry, and the universities. There may, however, be unusual kinds of basic research projects that merit EF interest.

Fields that seem especially appropriate for Engineering Foundation activity are: (1) engineering projects of general interest, similar to those now supported; and (2) projects to advance the engineering profession, including appropriate projects of an educational nature. As to projects for the good of mankind, up to now no constructive thinking has been forthcoming.

The Planning Committee is considering several questions regarding the future Foundation program. For one thing, Engineering Foundation has thus far tended to wait for deserving projects to be submitted. To what extent should it look around for worthwhile projects and ways to get them them going? Because the requests that come in each year are far in excess of the available funds, the aim in any such search would be to hit upon better projects, perhaps of somewhat different character. It might be possible, for example, to find more projects not clearly in the field of any one Founder Society, but on the fringe or in between.

Another question that the Planning Committee is considering is whether there is too much fragmentation of EF gifts. Might it make better sense to concentrate on fewer causes, rather than spread out as is done, with this year's 32 grants averaging $2,500 each? The answer would depend on discovering causes more unique than those currently proposed.

Still another query is whether an effort should be made to add to the present modest endowment. The consensus is that a program for this purpose should indeed be undertaken, but that it should wait until the Engineering Societies' building fund campaign is over.

Finally, the Planning Committee is firmly convinced that more and better ways should be sought for publicizing the activities of Engineering Foundation. But it does not quite know how to go about this. Madison Avenue techniques are viewed—let us be kind—with raised eyebrows. Maybe, as a starter, the Board should set aside a fund for better speakers.

Determining Reserve and Interconnection Requirements

H. D. LIMMER
ASSOCIATE MEMBER AIEE

UNTIL RECENTLY, the reserve requirements of a power system have been calculated either by applying a given percentage of reserve, or by counting on the outage of one or two of the largest machines. These standards generally are justified by the fact that satisfactory service has been obtained in the past by following them. Whether these rule-of-thumb standards will be valid under the conditions of the future is questionable, because the proportions of machine sizes to system size, as well as other characteristics that affect the required amount of reserve, can change considerably as time goes on. It is desirable to express a standard of service on a mathematical basis. Then all the factors that influence the standard can be analyzed separately, and any future system can be tested to see whether its service standard is equal to the present one.

The simplest mathematical method of determining the reliability of a system is to calculate the probability of loss of load. This quantity is defined as the probability that not enough generation will be available to satisfy all the load. It can be expressed either as a pure number between zero and one, or in such terms as "one day in X years." Probabilities of loss of load are generally assumed by planning engineers in the range of 1 day in 5 years to 1 day in 20 years.

A method of calculating the probability of loss of load has been developed. This method is adapted for the use of a medium-size digital computer. It takes into consideration the factors of machine sizes, machine forced-outage rates, possibilities of forecasting errors, the load duration curve, scheduled generator maintenance, and interconnections.

Fig. 1 shows the results of a typical study made with the use of the probability method. The study was concerned with a section of a power system, which was treated as a separate system for the purposes of this study. The section concerned had a total generation capacity of 2,532 mw, and 450 mw of firm interconnection capacity. The three curves in Fig. 1 represent the probability of loss of load as a function of the load, for three different assumptions concerning load forecasting errors.

The problem was to determine in what year this section would need relief either in the form of a load cutover to another area, or of additional generation or interconnection capacity. A probability of loss of load of one day in 10 years was selected as a standard. Under these circumstances, relief will be required in 1961 if the possibility of forecasting errors up to 19% is accepted. Relief can be delayed until 1962 if forecasting errors are thought to range only to 10%.

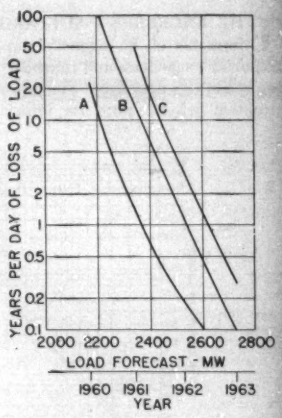

Fig. 1. Determining the year relief is required (A) with forecasting errors up to ±19%, (B) with forecasting errors up to ±10%, and (C) with no forecasting errors.

CONCLUSIONS

THE FOLLOWING CONCLUSIONS have been drawn from the limited number of studies made to date:

1. In the range of generally accepted reasonable values of probability of loss of load, the latter decreases very rapidly with small increases in interconnection capacity. The problem of selecting a reasonable probability of loss of load is, therefore, a relatively minor one. Any reasonable standard of probability of loss of load will indicate about the same capacity requirements.

2. The assumptions concerning the forecast accuracy are the most influential in determining the probability of loss of load, given a fixed amount of interconnections and reserve capacity.

3. The use of excessively large generators will cause an appreciable increase in the interconnection capacity requirements.

4. Minor changes in the generator outage rate also have little effect on the probability of loss of load. Therefore, the outage rate to be chosen for generating units or interconnections is not a critical value, as long as reasonable estimates are made.

5. For typical systems studied to date, a combined generation and interconnection reserve of 22 to 26% is required if 3-year forecasting errors up to ±10% are taken to be possible, but reserves of 30 to 35% are needed if forecasting errors up to ±19% are considered possible.

Digest of paper 58-139, "Determination of Reserve and Interconnection Requirements," recommended by the AIEE System Engineering and Power Generation Committees and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Magnetic Amplifier Design — Part I

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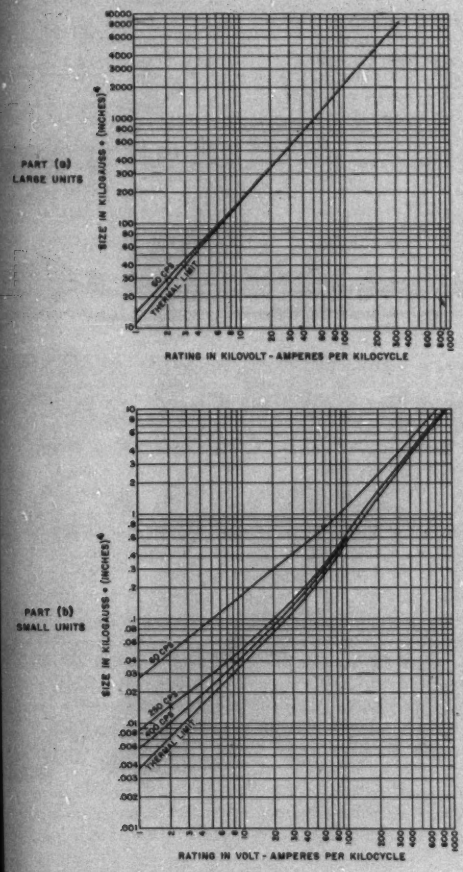
THE EXCELLENT SUITABILITY and fine performance of the magnetic amplifier in applications requiring ruggedness and reliability have led to increasing use of this device as a control component. From this situation arises a need for information and methods to be used in the design of the magnetic amplifier as a system component. With this background, an effort is directed toward presenting an organized collection of data which may be used in a practical step-by-step manner to design the toroidal magnetic amplifier. Although emphasis is given to the single-ended, full-wave, single-phase circuits, some approximate equivalence factors have been given for various other circuits. The scope is limited to the self-saturating type magnetic amplifiers. These techniques are arranged to save the component designer's time and thus expedite the engineering of magnetic amplifiers.



CORE SIZE BASED ON PRODUCT OF TOTAL WINDOW AREA • IRON AREA • STACKING FACTOR.
COPPER AREA BASIS IS 22.5% OF WINDOW AREA.
GATE WINDING ALLOCATED 60% OF COPPER AREA.
RATING SINGLE PHASE BASIS; FULL WAVE, SINGLE ENDED CIRCUIT.

Fig. 1. Toroidal amplistat core determination chart.

Using the general approach that the product of the window area by the iron area determines the rating capability of a core, together with the measurement of certain parameters which vary with size, design charts have been prepared to make the design calculation process simplified and straightforward. From the desired rating of the magnetic amplifier, a core determination chart (Fig. 1) is used to determine an appropriate product of core window area times core iron area for any design flux density. As shown, Fig. 1 incorporates both the flux density and power frequency in such a way that the chart may be used for various materials at any power frequency. Measurements on successful production magnetic amplifiers have been used to obtain assurance that each chart will yield practical results.

Utilizing materials chosen on the basis of the desired dynamic performance, the cost, etc., and having chosen a thickness of core material suitable for the power frequency of operation, the actual product of the iron area and window area is computed. A listing of cores is given to facilitate the choice of an actual core. This list contains the dimensions of cores marketed by many vendors, lists the cores in the order of size for quick design use, and shows the interchangeability between cores from different suppliers. In Part II on this subject, techniques are given for the winding design, completion of the design, and a checking process.

Thus, a method has been presented which enables the establishment of a core design for use in calculating the toroidal magnetic amplifier. In this process, the core design has been synthesized from the rating and performance requirements, thus freeing the designer from the necessity of having available detailed performance data on prior designs. The approach is straightforward and quick, thus permitting a substantial savings in engineering time and effort.

Digest of paper 57-922, "Magnetic Amplifier Design, Part I—The Core," recommended by the AIEE Magnetic Amplifiers Committee for the AIEE Pacific General Meeting, Pasco, Wash., Aug. 28-30, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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Magnetic Amplifier Design — Part II

R. E. ANDERSON
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THE MULTITUDE of different applications and performance requirements which have arisen for the magnetic amplifier produce a need for a quick and effective design technique. Specifically, a simple and practical approach to the design of self-saturating full-wave magnetic amplifiers may be found useful. This second, and last, part of the paper is concerned with the winding layout and winding design in amplifiers having toroidal construction.

In order to avoid extensive "cut and try" procedures, the approach is based on synthesizing the design from charts. Such an approach also eliminates the need for detailed data from previous equipment. Thus, the design is initiated by determining a suitable core and then designing an appropriate winding for this core.

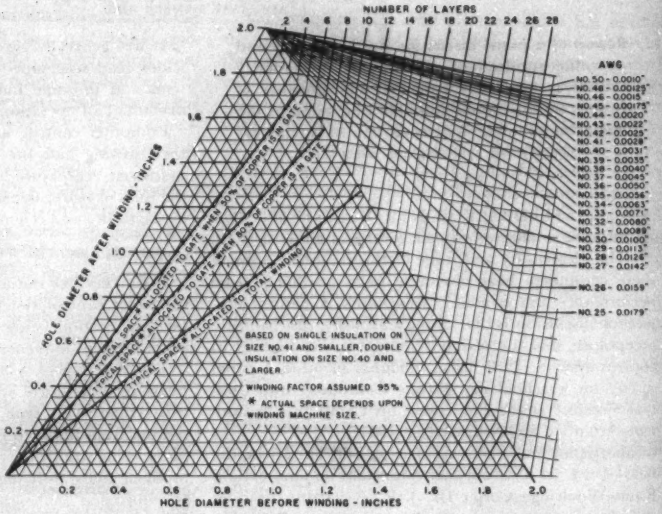
NUMBER OF LAYERS
2 4 6 8 10 12 14 16 18 20 22 24 26 28
AWG
NO. 50 - 0.0010"
NO. 48 - 0.0012"
NO. 46 - 0.0015"
NO. 45 - 0.00175"
NO. 44 - 0.0020"
NO. 43 - 0.0022"
NO. 42 - 0.0025"
NO. 41 - 0.0028"
NO. 40 - 0.0031"
NO. 39 - 0.0035"
NO. 38 - 0.0040"
NO. 37 - 0.0045"
NO. 36 - 0.0050"
NO. 35 - 0.0056"
NO. 34 - 0.0063"
NO. 33 - 0.0071"
NO. 32 - 0.0080"
NO. 31 - 0.0089"
NO. 30 - 0.0100"
NO. 29 - 0.0113"
NO. 28 - 0.0126"
NO. 27 - 0.0142"
NO. 26 - 0.0159"
NO. 25 - 0.0179"
HOLE DIAMETER AFTER WINDING - INCHES
TYPICAL SPACE * ALLOCATED TO GATE WHEN 50% OF COPPER IS IN GATE
TYPICAL SPACE * ALLOCATED TO GATE WHEN 80% OF COPPER IS IN GATE
TYPICAL SPACE * ALLOCATED TO TOTAL WINDING
BASED ON SINGLE INSULATION ON SIZE NO. 41 AND SMALLER, DOUBLE INSULATION ON SIZE NO. 40 AND LARGER.
WINDING FACTOR ASSUMED 95%
* ACTUAL SPACE DEPENDS UPON WINDING MACHINE SIZE.
HOLE DIAMETER BEFORE WINDING - INCHES

Fig. 2. Toroidal amplistat hole determination chart for small cores.

By analyzing the winding geometry of the toroidal reactor, it becomes evident that each layer has fewer turns than the previous adjacent layer. Furthermore, it was found that this change in turns per layer is independent of the relative wire and hole diameters; thus it can be shown that the winding geometry may be based upon the turns in the first layer of the winding. Starting the winding design in this way, the layout may be continued by evaluating the number of layers and available space with the aid of Fig. 1. Continuing this approach, Fig. 2 is used to find the hole remaining in the reactor after winding.

These techniques enable the preparation of complete reactor designs for magnetic amplifiers without the use of specific performance details from previous designs. The information is presented in graphical form, permitting modification for particular needs and simplifying the plotting of additional data which may become available.

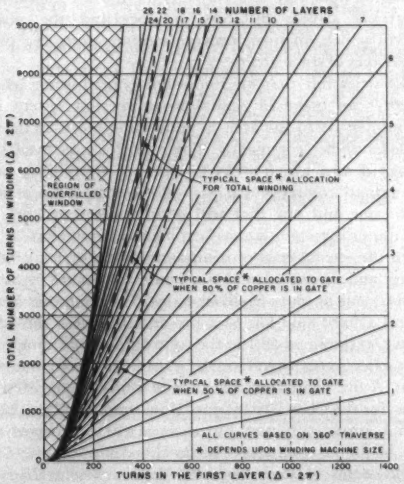
26 22 18 16 14 NUMBER OF LAYERS
24 20 17 15 13 12 11 10 9 8 7
TOTAL NUMBER OF TURNS IN WINDING (Δ = 2")
REGION OF OVERFILLED WINDOW
TYPICAL SPACE * ALLOCATION FOR TOTAL WINDING
TYPICAL SPACE * ALLOCATED TO GATE WHEN 80% OF COPPER IS IN GATE
TYPICAL SPACE * ALLOCATED TO GATE WHEN 50% OF COPPER IS IN GATE
ALL CURVES BASED ON 360° TRAVERSE
* DEPENDS UPON WINDING MACHINE SIZE
TURNS IN THE FIRST LAYER (Δ = 2")

Fig. 1. Chart for number of layers (large cores or small wire).

Digest of paper 58-39, "Magnetic Amplifier Design, Part II—The Windings," recommended by the AIEE Magnetic Amplifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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Fitting Computers into Control Systems

W. E. SOLLECITO
ASSOCIATE MEMBER AIEE

Report of a panel discussion on the present and potential applications of computers in feedback control systems. The extent of the influence of computers on control concepts and some of the obstacles to more extensive use of computers in control systems are discussed.

IN ALL FEEDBACK CONTROL SYSTEMS, some form of analog or digital computation is present. The elementary and some of the complex forms of these computers have obviously been justifiable from performance and economic viewpoints. A natural subject for discussion is that of the feasibility, justifiability, acceptance, and use of more and greater computers in control systems. With these thoughts in mind a panel discussion was held on "Fitting Computers into Control Systems" at the Conference on Computers in Control, Atlantic City, N.J., Oct. 17, 1957.

The panel was made up of men well known in the field—Dr. E. M. Grabbe, staff consultant on automation, Ramo-Woolridge Corp.; Dr. J. R. Ragazzini, head of the department of electrical engineering, Columbia University; J. F. Reintjes, director, Servomechanisms Laboratory, Massachusetts Institute of Technology (MIT); J. R. Moore, manager, Autonetics Division, North American Aviation Co.; E. W. James, engineering department, E. I. du Pont de Nemours Co. (Inc.); and H. T. Marcy, manager, Product Development Laboratory, International Business Machines Corporation (IBM). Chairman of the Feedback Controls Committee, H. Chestnut, served as moderator. An audience of over 250 was in attendance.

The objectives of the panel member presentations were to:

1. Indicate the extent to which computers have operated with control systems.
2. Explore the extent to which computers will operate as part of control systems with special emphasis on the industrial and process control area; i.e., industrial automation.
3. Set forth areas, jobs, or operating conditions in which it appears analog or digital computers seem best fitted.
4. Determine to what extent the use of computers in control will influence control concepts and analysis techniques as well as hardware and components.
5. Determine some of the obstacles to more extensive use of computers in control systems.

A special article recommended for publication by the AIEE Feedback Controls Systems Committee.

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It was generally agreed that computers have gained widespread acceptance and use in military control systems and in some industrial control systems such as machine tool operations.

Computer control, especially digital, is definitely on the upswing and the predominant factors governing industrial acceptance and use are not especially along the lines of better dynamic performance but along lines of reliability and economic justification.

ADEQUACY OF THE THEORY AND THE COMPONENTS

J. F. REINTJES initiated the discussion by classifying computer control systems into three groups—the basis for classification being the manner in which the computer element influences over-all system performance.

The first type of system he chose to talk about was a programmed control system or computer directed control system. This type of system operates in cascaded fashion from input to output, the function of the computer being simply to store a precalculated solution to a problem and supply the solution to the control element as required.

An example of a system of this kind is the digitally controlled machine tool systems which have been under development for the past several years. As now constituted, the input to these systems is in the form of coded number commands which describe cutting tool motions. A digital data processor converts the input command to electrical signals suitable for operating the power servos which, in turn, provide motion along the principal axes of the machine.

Reintjes felt that an important contribution which theory can make in digital machine tool system improvement is in the area of generating more easily the coded number commands. The need for improved language design which seeks to enhance the ability of a human to communicate with the computer is a very basic one and one that will occur more frequently as computer directed systems become more common.

In the second class of computer control systems, computer and control elements are interconnected in order to have one or more feedback loops. The computer again stores a fixed solution to a problem but now the computer is contained within the control loop and computer dynamics must, therefore, be considered in system design. A fire control system falls in this category. Up to now, for the Class 2 systems, analog computers have been almost universally used but there is a trend toward the use of digital computers to do the computation. This trend seems to stem from the desire to centralize all computations in a single element or unit and to gain the

advantage of accuracy and versatility of the digital computer. Because of the difficulty of getting digital computers to work in real time, consideration is also being given to combined digital–analog computation in which the arithmetic operations are performed digitally and integration is carried out in the analog domain.

Componentry here seems to be a key point toward the perfection of this kind of system since input quantities usually are in analog form and the use of digital computation presents the need for analog-digital conversion devices. Devices for coding mechanical and electrical quantities into numbers at present are undergoing intense development to improve their accuracy, reliability, operating capability, and extreme environments and to reduce their size and weight.

In the third class of system, the computer is again in the control loop but unlike its counterpart in the Class 2 group, it does more than perform a fixed calculation. Rather, it computes over-all system behavior and does something about it by making optimum use of the data which is fed to it. Furthermore, it makes use of data which cannot be predicted in advance. Some people envision this class of system as being the ultimate goal for the control of continuous processes. Before we can really incorporate such computers into chemical processes, for example, we will have to know much more about the processes themselves; in other words, process description becomes an important part of the theory behind these systems. Also, the definition and the development of meaningful performance criteria will be needed in systems of this kind. Relatively little is known about the criteria, for example, for selecting the best computer to fit a given system. System dynamics, stability, performance criteria, etc., must all be investigated from the viewpoint of optimum configuration. Furthermore, the processes themselves must be examined critically from the viewpoint of determining what are the key variables which must be controlled and, perhaps after these are known, an entirely new set of sensing devices may have to be developed in order to measure these key variables. Mr. Reintjes felt that bringing the theory of these systems, the Class 3 systems, and their implementation to a high degree of refinement presents a new challenge for the control engineer.

CONTROL SYSTEMS REQUIRING COMPUTERS

J. R. Moore started his discussion by suggesting that control systems involving computers be called "computrol" systems or "comptrol" systems. He liked the latter name better because it suggested complexity. He felt that where computers are needed to help solve control system problems, the control systems should be complex enough so that the addition of a complex computer is an economically justifiable addition.

Moore felt that if some future historian were to try to characterize the technology of our present era from the headlines in our lay press, he would write of this as an age of scientific breakthroughs in fields of nuclear energy, jet propulsion, supersonic flight, and giant electronic brains. But if he turned to the technical journals of our time, he could not fail to conclude that the most important aspect of the post World War II period has been the development of the technology of reliable complicated control systems. Without such control systems, none of the more sensational scientific achievements would be possible.

The computer is a new element which has entered the science of control system design to lead its breakthrough into applications having a complexity which would formerly have defied practical consideration. Development of reliable computers—particularly digital computers—capable of operating as integral parts of multivariable control systems, has permitted a generalization of input–output relationships which has expanded the number of uses of automatic control systems many fold.

Automatic control systems normally consist of four types of elements:

1. Meter elements, detectors, or transducers which measure physical inputs and outputs in terms of signals usable in other parts of the system.
2. Transmission links which interconnect the elements.
3. Power elements which take control information and make it available at the required power level.
4. Control elements such as signal amplifiers, power amplifiers, switches, analog computers, or digital computers.

In all control system designs, certain major pieces of the system must be considered unalterable—usually the power elements. The capabilities of these unalterable elements place an absolute limit on the capability of the outputs to achieve the desired relationships to the inputs. However, just as important and often more limiting in over-all effect are the amounts of uncertainty in the actual inputs or the measurements and conversions of the inputs and outputs performed by the detectors and transducers.

The function of the control elements is to mechanize acceptable mathematical approximations to the desired relations between inputs and outputs, taking into account the dynamical effects of power elements and detectors. Such a mechanization of mathematical relationships must include suppression of undesired signals or noise in the system as well as conversion of inputs into acceptable signals for transmission through the system and control of the power elements.

The more inputs and outputs a control system has, and the more complicated the desired relationship between these inputs and outputs becomes, the more important is the role played by the computer in establishing the performance and feasibility of the over-all system. Such computers may vary from the simplest type of passive networks integrally packaged with signal or power amplifiers to complete separately packaged high capacity digital or analog systems.

Analog computers cannot match digital computers in

accuracy, but often can perform simple computations more rapidly, more smoothly, and more economically than digital equipment. Digital computers have characteristics of high accuracy, great flexibility, and a capability of handling complex computations. They also have an advantage in the high degree of standardization of their components. Thus, a digital computer consists of large numbers of identical simple circuits which need only be reconnected in a different "logical design" to solve completely different problems. Digital computers also theoretically are attractive in that they can be designed to check themselves. In addition, they do not require the accurate control of voltage or current supplies because they operate essentially independent of the magnitudes of voltage or current provided these magnitudes exceed threshold limits. On the other hand, almost any malfunction in a digital computer may be catastrophic whereas in the case of an analog computer, malfunctions often merely reduce the accuracy of the computation.

The advantages of digital computers cannot fully be exploited as long as analog detectors must be used for primary input and output feedback quantities. This is because the accuracy, complexity, and reliability of the digital system is as dependent on the analog–digital converter (input–output equipment) as on the basic digital computer itself. The development of reliable digital transducers, thus, will enhance the attractiveness of digital computers for control system application.

Computers are necessary parts of control systems where these systems involve more than a single input and a single output, or where desired input–output relations can only be approximated by a mathematical relationship different from the input–output characteristics of the power element or of a simple feedback. Analog computers are useful where the computational elements of the system are secondary in complexity to the complexity of detectors and transducers. Digital computers come into their own where complex computation is required or where standardization and flexibility make possible the use of a standard computer for a number of different applications.

In all of this, the assumption has been implied that analog and digital computers have adequate reliability under the environment in which they must operate. Until quite recently, analog computers have had all the best of it for reliability under rugged environmental conditions. However, recent designs of digital computers have gone a long way toward solving the reliability problem, which earlier restricted digital computers to fixed installations. Thus, with the advent of transistors, printed circuits, and modern soldering techniques, the digital computer has begun to achieve degrees of reliability which analog computers cannot exceed. Such digital computers make it possible now to consider control systems of a complexity heretofore unthinkable. If analog-to-digital conversion equipment can keep pace in reliability, accuracy, and cost with the advantages in digital computers themselves, or if detectors with digital outputs can match the reliability and accuracy of their analog counterparts, we will see the day very soon when almost any multivariable system will be controlled by a digital computer.

THEORETICAL GAINS OF REAL-TIME CONTROLLERS

Dr. Ragazzini took a lead from Moore and coined the names "anatrollers" and "digitrollers." These names indicate the predominant type of computer in a control system.

There can be little doubt that computers offer increased flexibility although at increased cost and complexity. Assuming that the systems in question are of sufficient importance and of such economic or military value that cost factors are not dominant, or that they are multivariable systems previously described, then computers are necessary. And the question is—what type of computers should they be?

The analog computer, as Dr. Ragazzini interpreted it, is assumed to be capable of accepting continuous data, and to process that data to generate a continuous output or command signal which is applied to a plant or process being controlled. In doing so, it solves linear or nonlinear differential equations or mathematical relationships relating the inputs or outputs. In many cases, they may be one input and one output, or many inputs and many outputs. Taking the linear system as an example, the analog computer can be designed on the basis of cancelling undesirable effects, such as undesirable poles and zeros of the plant transfer function, and replacing them with desirable poles and zeros. The resultant over-all performance could then be described, after compensation, by its stable differential equation, or equations, dynamic properties of which are considered desirable. One fact remains, however, and that is that the system transient response in the time domain consists of the weighted sum of exponentials, and that for the system to reach a steady state or neutral state requires an infinite time. However, if the system reaches a condition which is within engineering specifications, it is acceptable.

Possibly, a more serious deficiency of a purely analog system occurs when one considers self-optimizing or self-adjusting systems, where an auxiliary computation is carried out to determine the index of performance of the system. This problem is of importance for those systems where the transfer functions vary continuously although slowly, where start-up problems are being considered, where the controller constants must, therefore, be adjusted continuously, but slowly, to optimize performance. Investigation will show that it is often simpler to carry out the auxiliary computation by numerical methods. Thus, an auxiliary computer is probably digital in form. This raises the question as to whether a fully digital or discrete system is not a better means for implementing the control system.

The use of digital or discrete controllers in linear systems has been studied under the general classification of sampled-data systems. The progress to date has resulted in the development of theory underlying the implementation of such systems in which the controller handles

the sequence of numbers at its input and delivers the sequence of numbers at its output. That such controllers should have certain advantages from a dynamic point of view was not fully appreciated until quite recently. For instance, it is possible to design linear systems the transient response of which are of finite duration over continuous times. This means that the system can be made to respond to an input or disturbance, such as a step, with completely deadbeat performance. By contrast, a continuous linear analog system cannot be converted into a deadbeat system no matter how complex the analog controller may be.

In addition to the fact the discrete controllers can be readily designed, there is the probability, as yet not fully realized, that nonlinear systems can similarly be controlled. These favorable factors, coupled with the fact that system characteristics can be obtained more readily and systems indexes of performance can be obtained more readily by numerical rather than analog methods, seem to raise the probability that the sophisticated systems of the future will be systems using discrete digital controllers which adjust themselves to produce optimum performance in the face of changing conditions. These are applicable, of course, in multivariable as well as univariable systems. The form of implementation, once the problem is understood, will be special-purpose digital or mixed computers which perform both active real-time computation and auxiliary optimizing computation. It should be emphasized, however, that such systems will probably be found in applications where the cost and complexity are warranted. However, there is also the strong possibility that digitally controlled systems for ordinary fixed constant performance, will also find adoption when they are implemented by highly efficient and economical designs usually mixed in nature.

In conclusion, discrete or digital computers, as well as analog computers, have much promise as control systems controllers and will find increasing acceptance in the control systems field.

SOME PROBLEMS OF ON-LINE COMPUTERS

E. W. James brought out that the complexity of chemical process control problems has for some time appealed to the control engineer as a fruitful area in which to apply novel and advanced control techniques; most recently, the use of on-line computing-control. And yet, in spite of the promise of better quality, higher yield, and increased productivity, the advent of large computer installations for direct control remains slow. He indicated some of the problems that appear to be the cause of this slow acceptance and showed what is being done to eliminate them.

First, the formulation of the optimization problem for most processes is incomplete. The interactions between various parts of the system are dealt with in a qualitative way by human operators and managers who may not have a full comprehension of a systems approach. As a result, the optimization pattern looks rather broad with little apparent incentive to stay directly at the center. We are attacking the system optimization requirement by attempting to formulate the over-all problem, with its interactions; quantitatively using the same feedback and dynamics techniques that are used for process control itself. In this way, the importance of the interdependence of various parts of the system becomes a matter of fact rather than opinion.

A second problem, somewhat related to the first, is the common feeling that processes cannot readily be characterized by the equations that would be necessary for a computing controller. Although there are many processes that will defy analysis for some time to come, there is sufficient data obtainable for most to be analyzed by simulation for test of various control methods. Basic theory, empirical data, and machine computation combine to permit analysis never before possible by pencil and paper.

Another barrier has been the process designer's view of computing equipment reliability. A different order of duty cycle is required for continuous processes that may run 24 hours a day for several months at a time. The past record on vacuum-tube computers has not been attractive, and the newer transistor types are still too new to be entrusted with any sizable portion of the control function. We are keeping a careful watch on the records of this type of equipment and are following an intermediate course of using it first in logging equipment so that reliability experience can be gained under actual plant conditions.

Another problem is equipment compatibility. As yet, no standards have been set for signal and matching characteristics. Furthermore, none of the standard-line instrument companies make computers, nor do any of the computer companies make a full line of compatible instruments. In the case of investments of the magnitude required here, designers are loathe to buy pieces of a system. They far prefer to buy a guaranteed package, with responsibility for operability fixed. Since this would require a systems study on proprietary data, usually under considerable scheduling pressure, the difficulty is doubly aggravated. Our approach has been to assist in preliminary computer planning wherever possible for forecasting our future needs to the best of our ability and making them known to those developing computer systems. The cost and time for system studies is being reduced by using the latest data reduction, computation, and simulation techniques to predict overall performance of the control system during design.

Probably the major barrier overshadowing any of those mentioned is that of economic justification.

First, it is recognized that a complete installed computer system of any size will be expensive dollar-wise, particularly if compared with the cost of classical instrumentation. This cost must be balanced by some potential return in reduced labor, increased productivity, or some other benefit. The theoretical potential gains can be calculated in dollars for any given process with a reasonable degree of accuracy. But two questions arise. First, of this potential gain, how much can we expect to capture by improved, more sophisticated control? Sec-

ond, if we put this money into other developments instead, would we realize a higher return? The answer to both these questions usually involves opinion. Again, the approach must be to attempt analysis of the situation quantitatively to reduce the opinion to fact.

Although there are many cases where existing plants will show clear justification for on-line computer installations, the real incentive will be in cutting capital investment by designing the basic process around computing control possibilities, and, at the same time, maintaining throughput and improving product quality.

The purpose of these comments was not to discourage the use of computers for process control, but rather to help bring computers into use sooner by facing the problems that exist, so that we may attack each one in a suitable way.

DIGITAL COMPUTERS IN CONTROL SYSTEMS

DR. GRABBE POINTED OUT that computer usage is directed toward systems that are going to make industrial and military systems more completely automatic and that, in his opinion, the paths are leading unmistakably toward the greater use of digital computers.

He stated that experience is being accumulated in the use of digital loggers, test data reduction systems, and military weapons systems. There are a number of joint ventures under way in which instrument and electronic companies are co-operating with industry in control system studies leading to the use of digital computers. Typical industries involved are steel, chemical, petroleum, and utilities.

Now, with the advent of solid-state and magnetic core techniques, a new order of computer reliability has been attained. The digital computer has reached a development stage at which many companies, both users and manufacturers, are giving serious consideration to digital computers for on-line control of industrial processes. During the past 5 or 6 years, the number of business computers in use has roughly tripled each year. It remains to be seen whether a corresponding growth can be attained by computers for process control.

The usual improvements that are seen for digital computers are increased production, improved quality, and reduced costs by optimizing process control. A digital computer may also be used as a data logger or recorder. In this capacity, using its computing and storage ability, it can evaluate process techniques and analyze operations. The wide use of data loggers has come about as the result of the need of both engineering and management to know more about plant operations. A computer logger will not only log data but will make dynamic analyses and print out results. If the system is interrupted for any reason when it is back on-line, the computer can interpolate between the last stored value for a quantity and the new value to give an average value over the period of interruption. Such a technique would provide good values for quantities such as cumulative production, material inputs, etc. For pilot plant operation, a computer-logger should speed up evaluation of process design characteristics.

As a controller, the computer can make multiple adjustments for optimum control. An output variable may be uncoupled when required. That is, it alone may be changed while other outputs are held fixed. In optimizing, a computer system will adjust set points continuously for optimum control rather than operating at given set points.

Many control engineers are doing systems engineering today on industrial processes. As a rule, such studies will not lead to computer control for the objectives are different. Such systems analysis set limits for the process that may encompass a large system at the outset but the trouble spots are soon isolated and the major effort goes toward dynamic analysis and corrections of difficulties in parts of the system. The control engineer directs his efforts toward minimizing variations of a few variables about a selected operating point.

When computer control is considered, on the other hand, the system limits are not reduced although parts of the system may receive considerable attention. New operating levels that optimize performance are sought and are re-evaluated constantly, always keeping in view the over-all system objectives.

In many cases, the control problem is such that hand computation and manual control would suffice. However, such computations may be complicated and involve charts and nomographs. It is questionable whether the caliber of manpower required to do this computation on an around-the-clock operation could be kept on such a job. Hence, computer control is the only alternative to attain the benefits of computing in control.

Dr. Grabbe predicted that in the next year industry will install two or three computers for initial computer application. He predicted that in the coming year, experience will be gained in the use of digital control systems, and will find many benefits that we cannot evaluate and estimate in advance.

COMPUTER MANUFACTURER'S VIEW

H. T. MARCY FELT that modern data processing systems and modern feedback control systems have grown out of separate pasts. It is now apparent, however, that data processing and feedback control systems are approaching, in many instances, single goals.

Apparently, there are a number of places where one can hope to expand the scope of feedback control by the application of certain types of computation.

First, it seems that computers might be used effectively in the class of derived measurements. Here, the computer might be used to join the data from a number of primary measurements and compute quantity or quality of particular importance to control. There is, however, another important class of operation. In modern digital computers, memory is getting cheaper. The results of detailed analysis may, therefore, be taken from products over the years and stored in memory under known operating conditions. The computer, by various types of information cataloging techniques, would be able to refer to these data and get a first order approxi-

mation to the situation that presently exists without waiting for laboratory analysis.

Another important application of computers and feedback control systems has to do with the concept of feed-forward. An example is in managing the process under some extremely large nonlinear transient conditions. The computer would take into account the process dynamics, saturation points in the process, and direct the process obeying the rules governing protection of the product and/or the safety of the plant.

Where a process is subject to changing dynamic conditions, auto- and cross-correlation functions can be used to take note of this. Such a system could use a computer closely associated with it.

Marcy does not favor the use of a centralized computer for the purpose of controlling the dynamics of a complicated process plant. The reason for this is the need for providing standby operation of the plant in the event that the computer needs servicing. No matter what degree of reliability is designed into this equipment, it is likely to be desirable to have standby operation.

Those engaged in the use of computing equipment for data processing in industry are very much attracted to the concept of business management of various types of process operations. By careful application of some form of optimizing supervisory controls, taking into account business needs and maximum profits, it would seem the computers could be a tremendous adjunct to process control. Whether or not this needs to be done as a direct part of the operation is probably subject to some question. Certainly, many companies are now using computers to assist them in determining what products they should make from a particular mix of input. Simulation techniques are playing an important role in this. We can expect much more of this to be done as we learn more and more about the physical nature of the processes we are attempting to control. The control industry already uses much equipment originally conceived for data processing in the field of data reduction, data logging, displays, separation of reports, etc.

Marcy felt that the primary obstacle in the use of computers in control systems to a great degree has been the definiton of the problem to a sufficiently understandable extent. People brought up in the school of feedback control systems underestimate the power of a computer to perform logical operations quite apart from the mathematical relationship of input and output variables. A great deal of understanding of the digital process will be necessary before we can completely capitalize on the use of this class of equipment. We must not underestimate the problems of programming and the problems of properly applying numerical analysis techniques. The cost of learning how to use computers in process control will certainly be high, thus making it difficult to define a tangible profit.

Marcy felt that computers of almost any reliability can be engineered, at a price, and that this situation can be expected to improve as more solid-state devices are employed.

DISCUSSION

SPURRED ON by the foregoing panel member commentary, many interesting and thoughtful questions and ideas were contributed by the audience.

Transducer Development Compared with Control Systems. David Spooner of Industrial Nucleonics Corporation felt that we might be held up in many cases by lack of transducer development.

Moore replied in the affirmative. He agreed we need more reliable transducers.

Grabbe noted that when analyzing systems with the idea of using computers for control, it was invariably found that there are new types of measuring instruments that could be very useful. The advent of computer control is going to be a big incentive for the instrument field to come up with some new transducers for measurement and actuation.

Why High-Speed Control? James Pritchard of the Foxwell Co. questioned the need for high-speed control in process control. He mentioned, for instance, that the high forces incurred in rapidly opening or closing a large valve could cause trouble. To use the latent speed here would involve complete plant redesign.

Dr. Ragazzini replied that fast control did not necessarily mean shortest time control but instead it assured optimum control of the plant variables.

James agreed that the real incentive is going to come when the plant is completely redesigned with the possible control functions in mind. He pointed out that in chemical process systems, system designers are proud of the flywheel effect afforded by large inertias which make the systems inherently more stable. These inertias cannot be jockeyed around very much and in present plant design we cannot expect to do anything very sophisticated.

Process Engineer Agrees. William Field from Union Carbide Chemicals Co. agreed wholeheartedly with the problems mentioned by James and went on to say that his company is using analog computers to study chemical processes. A very real problem is the way processes are designed; so many different people are involved in the design of the various portions of a process that no one man has an over-all picture of the whole process. For integrated computing control, the system must be looked at as a whole.

During the discussion, Moore threw off his engineer's mantle and assumed that of a manager, pointing out that there are many other than strictly technical factors that can sometimes be used to convince management that they should utilize computing control. For example, reduced labor force requirements might permit a plant to be moved from a city with 20,000 population to one with 5,000 population, with attendant savings. Conclusion: when trying to sell computing control to management, don't overlook any of the related problems. Make sure you take the over-all systems approach and note every gain possible whether directly connected with the controlled process or not.

Iron and Copper Loss Measurement in Transformers

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MEMBER AIEE

L. B. RADEMACHER
MEMBER AIEE

H. R. MOORE
ASSOCIATE MEMBER AIEE

IT IS HIGHLY DESIRABLE to improve the accuracy of measurement of transformer iron and copper losses. Unless accurate measurements are available, it is difficult to evaluate the benefit of modifications in processes and constructions intended to reduce the winding eddy losses, stray losses in the tanks, and the iron loss.

It is usually assumed that the iron loss of a Y-delta connected transformer is the same whether measured from the Y or the delta side. Some recent tests made with a nonsinusoidal applied voltage showed differences. The losses were greater measured from the delta side. However, the standard formulas[1] for correcting for voltage wave form apply if the voltage is measured properly. The manner in which the harmonic voltages, principally the fifth and seventh, combine with the fundamental voltage results in the line-to-line voltage wave form being different from the line-to-neutral wave form. The line-to-line voltage, as measured with a rectifier voltmeter, may not be equal to $\sqrt{3}$ times the line-to-neutral voltage.

The standard method[1] for correcting iron loss for the effect of voltage wave form essentially requires that the peak flux in the core be measured, which is proportional to the rectifier voltmeter reading on a winding about the particular flux of interest. For the Y-connected winding, measuring the voltage from line to neutral is basically correct. Inasmuch as there is no simple relation between the line-to-line and line-to-neutral rectifier voltmeter voltages, the Y-winding line-to-neutral voltage desired should be measured directly. If the transformer neutral is not available, a Y-delta potential transformer may be used. for a delta-connected winding, the voltage should be measured from line to line; not from line to neutral.

Most engineers understand the errors that result from instrument transformer phase-angle errors, meter phase-angle errors, and the meter magnitude errors on single-phase copper-loss measurements, but there is less understanding of the errors in 3-phase measurements and the probable error in measurements after all possible corrections have been made. These problems are greater in large power transformers, because of the low power factor. The probable error resulting from several independent probable errors is $\sqrt{e_1^2 + e_2^2 + e_3^2 + \cdots}$

An analysis based on a 25% power factor, 125-watt wattmeter showed that the probable error would be 5.9% with a 1% power factor single-phase load.

The inductronic product resolver made by the Weston Electrical Instrument Corporation improves the accuracy of low power factor measurements because it has a low phase-angle error and because different scales can be used to obtain large deflections at low power factors. At 1% power factor, the probable error is 4.8%.

A power factor bridge has been developed for accurate measurement of low power factor losses. Accurate components are used in this circuit so that the power factor of low power factor transformers is measured accurately. The National Bureau of Standards measured a power factor of 0.02165 on an experimental reactor,[2] and a reading of 0.02172 was obtained with the power factor bridge. The probable error at 1% power factor is 1.5%.

An analysis of the 2-wattmeter method for measuring 3-phase losses showed that the probable error is 13.8% at 1% power factor. The large error is principally caused by the two readings being close together at low power factors so that a small error becomes significant. This method should not be used to measure low power factor losses.

Single-phase methods can be used to measure 3-phase power by using one instrument per phase. The probable error is then the square root of the squares of the individual errors. Fig. 1 shows the comparison of the different methods for measuring 3-phase losses.

The data presented is necessarily approximate, but Fig. 1 shows that large errors can result if some methods are used for low power factor measurements. The method to be used for measuring losses in large power transformers must be carefully selected to prevent large errors.

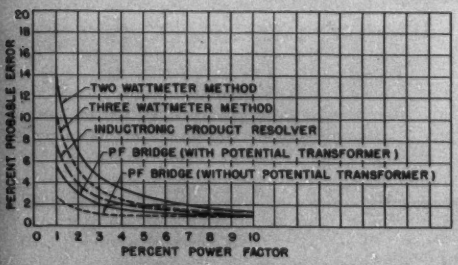
PERCENT PROBABLE ERROR
PERCENT POWER FACTOR
TWO WATTMETER METHOD
THREE WATTMETER METHOD
INDUCTRONIC PRODUCT RESOLVER
PF BRIDGE (WITH POTENTIAL TRANSFORMER)
PF BRIDGE (WITHOUT POTENTIAL TRANSFORMER)
0 1 2 3 4 5 6 7 8 9 10
0 2 4 6 8 10 12 14 16 18 20

Fig. 1. Comparison of probable errors for the different methods of measuring losses in 3-phase circuits.

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Limiting Values of Impedances and Transfer Functions

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ASSOCIATE MEMBER

IN DESIGNING electrical circuits it is often important to know the bounds of the magnitude and phase of impedance networks. For example, it is necessary to know impedance variations when designing devices to drive these networks. The effect of variations on gain and phase of transfer functions is particularly important in closed loop servo systems for stability considerations. A method is suggested which will determine precisely the effect of component tolerances and frequency variations on the magnitude and phase of transfer functions. Conversely, allowable tolerances can be set on these quantities.

The method consists of finding a set of equations that define the bounds of the impedance or transfer function due to circuit tolerances. These equations are determined by a conformal mapping technique using the limiting values of the component as established by the tolerance. This always results in a set of equations which define the limiting cases; each individual equation describes a line or a circle, and these lines or circles form a closed region showing the variation of the impedance or transfer function.

The method is illustrated by a discussion of the circuit shown in Fig. 1. Equation 1 describes the input admittance of the circuit for a specific sinusoidal frequency.

$$u + iv = \frac{j}{X_c} + \frac{1}{R + j X_L} \qquad (1)$$

By solving this equation and letting the components assume the limiting values, a set of equations is obtained that determines the limit on the input admittance variation. A $1/Z$ transformation* of these equations will yield a set of equations which establishes the bounds on the impedance variation of the circuit of Fig. 1. A

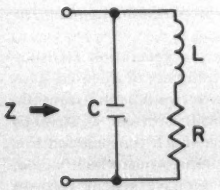

Fig. 1. Driving point impedance example, with parallel tuned circuit.

typical example of the impedance bounds established by this method is shown in Fig. 2.

The effect of frequency variations can be evaluated by considering the impedance variation of the frequency dependent elements. This method could be used in evaluating networks at carrier frequencies. The method does not give the type of information found in Bode plots; however, it might be useful in evaluating the effect of component variations at some point such as the notch frequency of a twin tee network.

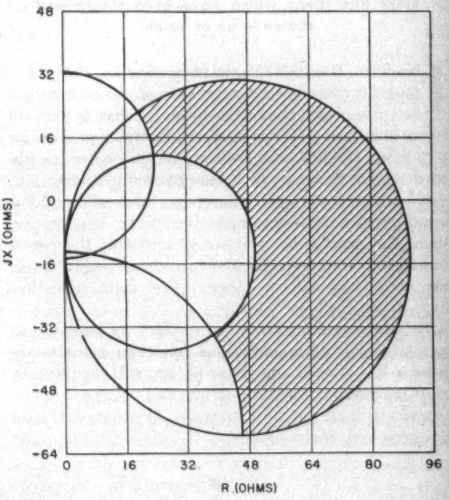

Fig. 2. Example of input impedance variation with tolerances of the circuit shown in Fig. 1.

Very little analytical effort has been devoted to the unglamorous task of defining and evaluating the effect of component tolerances. It is believed that two valid statements can be made concerning the proposed method:

1. The effect of component and frequency variations on transfer functions and driving point impedances can be established within precise bounds.

2. The method is superior to the practice of varying a few circuit parameters at random and considering this a complete evaluation of circuit tolerances.

Digest of paper 58-81, "Limited Values of Driving Point Impedances and Transfer Functions due to Component Variations," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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* Complex Variables and Applications (book), R. V. Churchill. McGraw-Hill Book Company, Inc., New York, N. Y., 1948, chap. IV.

An Ideal Electrical Layout for a Textile Mill

M. V. GELDERS

Numerous factors applicable to the design of an electric system for a textile mill are discussed. In order to achieve an "ideal" layout, the design engineer should take advantage of new equipment and ideas which have been tested and shown to be of value.

IN THE DESIGN of electrical layouts, there is a constant effort toward improvement, coupled with a desire to obtain improvements at less cost or with no increase in cost. The value of new materials is continually being checked, and the application of new equipment and new ideas are constantly being studied and evaluated. Things new will always offer the greatest opportunities for progress and for failure. It is proper, then, that caution be exercised in initiating the use of new things; but we must stand ready to accept them, use them, and improve them when their value has been established.

It is the intent of this article to point up some things new which, it is thought, have had their value established. It is hoped that these things will supplement and augment our electrical designs and that some of our shackles will be loosened by them. Experience to date has been very encouraging.

FACTORS

IN DEVELOPING this "ideal electrical layout" for a textile mill, the definition of the word "ideal" is taken to mean "something very desirable." Basically, any electrical system can be termed ideal which provides adequately for the following:

1. Safety to personnel and equipment.
2. Uninterrupted production.
3. Long life and low maintenance cost of equipment.
4. Over-all economy in textile mill operation.
5. Flexibility for possible plant changes.
6. Capacity for load growth.
7. Provision for future plant expansion.
8. Good voltage regulation.
9. Good lighting.

To provide adequately for these features requires different installations for different situations. Even identical mills located in different areas usually require variations in the electrical design to be on a comparable electrical basis. Climatic and geological conditions, the source of electrical energy, and the technical ability of the operating and maintenance personnel are all important factors in selecting the features and components of an electrical design. The dependability and nearness of electrical contractors and electrical supply companies exert an influence upon electrical design.

On reviewing some of these factors which necessitate variations of design in identical mills producing identical goods, it is readily understandable that the variations can be multiplied many times over when comparing mills of different size and different physical layout producing different types of textiles.

The electrical requirements for a textile mill are usually less demanding than those for some of the continuous-process chemical plants, and the electrical installation can be of a more simple design. Even so, the reliability of the textile mill's system will closely approach the most complex electrical system in use in any industry. This can be considered a tribute to the accomplishments of the manufacturers of electrical materiel. Present-day switchgear, transformers, and cables are splendid testimonials to the progress made toward reliability and safety. Better methods of production and testing, in conjunction with improved designs, have given us equipment in which our full confidence is almost always justified.

This hypothetical textile mill is assumed to be a 1,000-loom cotton mill on print goods without finishing. It is of slab-on-grade construction having steel framework of one-story design with 300,000 square feet of area. The building is 400 feet wide by 750 feet long, containing cotton warehouse space, opening and picking, carding, spinning, yarn preparation, weaving, inspection, and cloth warehouse.

This mill does not have power generation facilities, but it is served by the power company in the area. This might make it desirable to have two separate transmission lines serving the plant load, with one as stand-by in event of failure of the other. Each transmission line could serve a separate power transformer which would, in turn, serve one primary selective system through metal-clad switchgear.

This general scheme of design could be developed right on through the unit substations and secondary feeder systems. There are occasions when some, or perhaps all, of these features are merited by the electrical needs of a textile plant. However, because of the splendid record of service continuity which most power com-

Full text of a conference paper presented at the AIEE Textile Electrical Conference, Atlanta, Ga., Mar. 13-14, 1958. Recommended for publication by the Textile Industry Subcommittee of the AIEE General Industry Applications Committee.

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panies can show their lines to have, because of the extremely low failure rate in liquid-cooled transformers of only 1 in 1,500 transformer-years, and because of the low failure rate in plant primary cables of only 1 per mile per 100 service-years, we are fortunate in not often having to invest in expensive duplicate equipment. This high degree of reliability is the combined result of dependable quality in manufacturing and improved techniques of installation.

Taking advantage of this experience record, we can eliminate one of the aforementioned transmission lines, one of the power transformers with its associated metal-clad switchgear, and the primary selective system. To avoid the annoyance sometimes caused by lightning outages of an instantaneous nature, the electrical installation should include time-delay stations on all important motor circuits, particularly those normally unattended, such as the air-conditioning and refrigeration equipment.

In this ideal electric system the power transformer would have load ratio control to assure the maintenance of voltage within very close limits. Because the anticipated power demand for this plant is 5,000 kva, the power transformer should have 7,500 kva capacity to provide for future growth in electric load.

To reduce the hazard of lightning getting on the plant's distribution system and to minimize the voltage drop between the main substation and the mill, the transformer would be located on the mill property. The transformer would be protected on its primary with station-type lightning arresters and would present a buffer against lightning surges. For added safety, magne-valve type lightning arresters would be connected to the bus of the circuit breakers serving primary feeders to the mill.

Two power air circuit breakers of 1,200 amperes continuous duty and 250 mva interrupting duty would serve two 13.2-kv feeder circuits to the mill. These power circuit breakers would be installed as an outdoor switchgear unit with provision for adding future circuits. Metering to indicate total amperes, volts, and kilowatts would be provided for this primary switchgear. The current in outgoing feeders would also be metered. A recording demand meter would give information from which to schedule heavy electric loads.

GROUNDING

THE POWER TRANSFORMER would have a main ground network interconnected by not less than 4/0 copper conductor and would provide a maximum ground resistance of not more than 1 ohm. All ground connections would be cad-welded. To this station ground would be solidly connected all lightning arrester grounds at the substation, all steel columns of the superstructure, and the transformer tank.

A separate grounding system would be located remotely from the main substation ground network, preferably more than 50 feet away. All ground wires of the outgoing feeder circuits would be solidly connected to this ground through the switchgear ground bus. The secondary neutral of the main transformer would be connected to this ground through a resistor. The resistance of the ground would be not more than 1 ohm. Also connected to this ground by 4/0 bare copper cable would be the grounding network, buried at least 18 inches below grade around the perimeter of the building, extending to some interior columns and to all unit substations. Grounding electrodes every 200 feet around the building and at each unit substation would be connected to this network. These electrodes would each have not more than 5 ohms resistance. The steel structure of the building would be bonded to this grounding network at frequent intervals. Connections would also be made to the underground water piping at convenient locations.

FEEDERS

TO CONVEY POWER into the mill, underground feeders in ducts would be used. One well-drained manhole of liberal size between the outdoor switchgear and the mill would assure relatively dry ducts at all times. The two active feeder circuits would each consist of three 3/0 conductors fully insulated for 13.2-kv ungrounded, and one 3/0 TW insulated ground wire. To avoid the use of potheads, the line conductors would be insulated with Butyl rubber protected by a neoprene jacket. Normal shielding and taping would be used. All stress cones at terminations would be very carefully made and would provide at least a 20-inch length of insulation between the termination of the shield and termination of the conductor. Each ground wire and shield would be connected to the ground bus of the switchgear.

Four ductways would be provided between the primary switchgear and mill—two active, and two spare. It would be desirable to have spare conductors installed with suitable terminations to facilitate rapid and safe changeover with power off.

Where the underground power feeders enter the building, an air terminal junction box would be provided for connection of interlocked armored cable to the underground feeders. Beyond this point, the 13.2-kv primary distribution would be accomplished by 3-conductor 3/0 interlocked armored cable having three 15-kv ungrounded-neutral Butyl-insulated conductors. Three no. 3 bare copper ground wires would be run in the interstices of the cable. All no. 3 ground wires would be solidly bonded to the air terminal junction box and to the 3/0 ground wires in the underground service from the main switchgear. The cable supporting racks and the interlocked armor of the cable would be aluminum. Connecting sections of racks would be bolted to afford a good supplementary ground path for fault currents with the racks solidly grounded to the air terminal box.

SUBSTATIONS

THERE WOULD BE six unit substations of 1,000 kva each. Each primary feeder would serve three substations. Provisions would exist to loop through the last unit substation on each circuit for service to a future fourth

unit substation. Secondaries of the unit substation would be connected for 480 Y/277 volts. The neutral would be solidly grounded to the switchgear ground bus which, in turn, would be grounded to the unit substation grounding electrodes. All ground connections of feeders, ground bus, and grounding network would be joined at each unit substation.

Each unit substation would have a primary disconnect switch with power fuses. The switch would be key interlocked with the secondary main air circuit breaker, and the fuse compartment would be key interlocked with the interrupter switch. The incoming line section would provide ample space in the air-filled compartment for the installation of full-sized stress cones. The transformer would be an askarel-filled type with four 2½% rated kva taps in the high-voltage winding. The maximum asymmetrical fault current on the secondary winding would be approximately 32,000 rms amperes including motor contribution. All secondary air circuit breakers would be metal-clad draw-out type, triple-pole single-throw, electrically operated with control switches, and would have instantaneous and time overcurrent trips. The main secondary breaker would be rated 1,600 amperes continuous at 600 volts, and have an interrupting rating of 60,000 rms amperes at 480 volts. All fully rated feeders, 600 amperes and below, would have interrupting ratings of 35,000 rms amperes at 480 volts. In general, all feeder circuits would be of 400-ampere capacity or less. Exceptions would be feeder circuits serving large refrigeration motors for the air-conditioning systems.

The secondary power distribution would utilize plug-in bus duct and interlocked armored cable wherever feasible. A half neutral bus in the bus duct and bare copper ground wires in the interstices of the interlocked armored cable would serve as positive equipment grounds. A continuous grounding conductor would connect each motor frame and metal enclosure to the ground bus.

All fluorescent lighting would be served directly from the 480 Y/277-volt system with the neutral brought out for this purpose. Equipment ground wires, separate from the neutrals, would connect all lighting fixtures and panel boxes to the ground bus. Each fluorescent lamp ballast would be protected by an individual fuse mounted in the fixture housing.

Color coding of conductors would be used throughout the mill. Red, blue, and black would identify the phase legs, white would identify the neutral, and green or bare copper would identify the grounding conductor. Except where short runs of small conductors might be involved, no conductor would be subjected to fault currents which would damage the insulation.

No motor starter, switch, device, or bus duct would be subjected to fault currents in excess of its rating. Where the fault current magnitudes had not been sufficiently reduced by the length of feeder and branch circuits, current-limiting fuses would be employed to protect the equipment or conductor. Where precautions might be necessary to avoid possible single-phasing, combination circuit breakers and current-limiting fuses would be employed. The circuit breaker would handle faults within its rating and would interrupt all three phases if the current-limiting fuses were called upon to interrupt faults above the breaker rating.

In general, conductor sizes would be selected to allow more than the minimum National Electrical Code requirements. Except where conduit runs are short and quite straight, the conduit sizes would be selected to give greater than minimum requirements. To illustrate, a motor having a full-load current of 15 amperes would be served by no. 10 conductors in lieu of no. 12. With four no. 10 conductors required, including the ground wire, a 1-inch conduit would be used in lieu of a 3/4-inch conduit, unless the run was short and straight. Standardization of conductor sizes would be used to the optimum economic advantage and to reduce the sizes and types of conductors required in replacement stocks. Type SO cord would be used extensively for short connections between motor starters and motors.

Except where standardization suggests that it should be otherwise, main feeder circuits overhead might be VC, RH-RW, or RHW. Where several feeders are run adjacent, the use of interlocked armored cable would be commonly used. Where feeder circuits or motor circuits of more than 400 amperes are required, parallel conductors would be used. Parallel conductors would be derated approximately 10% in capacity to allow for unbalance in current distribution. The RHW insulation would have a neoprene jacket to resist oil. All insulated ground wires would be of TW insulation.

In areas subject to frequent fire damage, such as the picker room lint filters, silicone-insulated conductors with glass-fiber or asbestos braid in conduit would be used to minimize likelihood of damage to the insulation. Silicone-insulated conductors would also be used wherever ambient temperatures are high, such as around the slashers and in the boiler room.

The opening and picking areas would be served by motor control center installations of dust-tight construction.

Card starters with reversing features would be served by type RHW insulated wire in underfloor conduit with a TW insulated ground wire. Except where impractical, all splices would be made in boxes above the floor level. All starters and switches would be enclosed in NEMA (National Electrical Manufacturers Association) type 12, or better, boxes. Other carding and spinning machinery would be served in a similar manner.

Winding, quilling, spooling, warping, slashing, and tying in would utilize wiring from overhead wherever possible. Bus-drop cable and type SO cord would be used from overhead where conduit is not required. Where conduit is required, type RHW would be used for standardization purposes and because of its good qualities. The cloth room would be wired similarly.

Inasmuch as this would be a new mill with wide column spacing, the use of column-mounted loom switches would not be too feasible. To make this installation ideal, we would like to see a new loom switch developed

which would be suitable for mounting directly on the motor bracket of the loom. It would be vibration-dampened, be completely sealed, and have stab-on contacts. The female connector of the stationary mounting unit would be served by an SO cord connected to a twist-lock receptacle beneath the loom. Plastic-coated panels, conduit, and devices in the weave room would assure maximum life expectancy in the high humidity. Fusible distribution panels with high-current-interrupting switches would serve the 30-ampere loom circuits of eight or nine looms each through no. 10 RHW conductors in underfloor conduit. Each distribution panel would have 18 active circuits and two spare circuits. The panels would be served by 250-MCM (thousand-circular-mil) VC conductors from electrically operated 600-ampere circuit breakers in the respective substation. A remote push button at each panel and paralleled at any desired common location would control the circuit breaker operation.

LIGHTING

EXCEPT FOR SPECIAL REQUIREMENTS, all lighting would be rapid-start fluorescent or slimline. Ballast voltage would be 277 volts, and service would be directly from the 480 Y/277-volt distribution system through current-limiting fuses ahead of 277-volt circuit breaker panels. Single-pole circuit breakers for lighting circuits would be rated for 10,000-ampere interrupting duty.

The lighting layout would emphasize concentrating light on the working areas, with general illumination a secondary, although still important, consideration. Of course some areas, such as weaving, would have uniform general illumination. There would be no sharp contrasts in illumination levels in any areas, either vertically or horizontally. Luminaires having upward components in conjunction with white, or light colored, ceilings would keep contrasts to a minimum.

Porcelain-enamel reflectors would be standard, and in high humidity areas the channels would also have porcelain enamel surfaces. Ballasts and sockets of all fixtures would be of the very best quality.

Lighting circuits generally would be switched at circuit breaker panels conveniently located in the area. However, a selected number of lights would be controlled remotely to permit the watchman or others to walk through the plant during shut down, turning lights on when entering a room and off when leaving. Emergency lights, battery operated, would be mounted on columns and walls throughout the plant to illuminate the exits and paths of egress on occasion of a power failure. Battery cases would be constructed of stainless steel, or be rubber covered, to prevent acid damage.

Power for convenience outlets, incandescent lamps, small appliances, etc., would be furnished by 3-phase dry-type transformers connected 480 volts delta on the primary, and 120/208 volts Y on the secondary with four fully rated 2½% taps. Convenience outlets would all be of the grounding type. They would be located on each column and at reasonable intervals on each wall.

Power outlet receptacles at 208 volts and 480 volts would be provided as required for the portable tools, welders, and cleaning equipment.

Unit substations would provide metering for volts, amperes, and killowatts with the current in at least one phase of each feeder circuit metered.

When required for power factor correction, capacitors switched with the individual motors would be installed wherever practical. For economic reasons, capacitors for loom circuits would be installed at the distribution panel.

When starting large centrifugal fans or other high-inertia loads across-the-line, shunt reactors in the motor starters or low starting current motor designs would be used.

Not previously mentioned, but not to be overlooked, is the use of best quality conduit, fittings, tapes, connectors, boxes, and other components required to complete every electric system, as well as good workmanship, so necessary for even the best of equipment and material to perform correctly and to give trouble-free service. There is no place for even one careless splice or one loose lock nut in an ideal electrical layout.

CONCLUSION

THIS ARTICLE has not suggested that existing electrical layouts be changed to conform, nor does it imply that every new electrical layout should conform. With the use of different voltages, different transformer connections, different conductor installations, and different equipment, there will continue to be electrical installations which should rightly be termed "ideal." Some features will, of course, remain basic to all. However, it appears that most, if not all, of the features described will become increasingly commonplace in the textile industry.

Elevator Test System

A continuing check on the performance of new elevators is maintained in a test tower by the Elevator Division of Westinghouse Electric Corporation, Jersey City, N. J.

Test data on such performance factors as car velocity, generator voltage, field current, and relay response time are accurately recorded for analysis by means of a portable recording system, manufactured by Brush Instruments, Division of Clevite Corporation, Cleveland, Ohio.

Tests are run against a predetermined operating norm or "command" operation. As the elevator starts, a "command" pattern is traced on one channel, while other channels simultaneously record actual performance data. Instant or later comparison shows how much actual performance data varies, if at all, from preset figures.

Magnetic Materials in Ultrahigh Temperature Electronic Transformers

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Equipment and components to be used in modern aircraft and missiles must be capable of operating at extremely high temperatures. Experimental work has been performed to determine quantitatively the effects of temperature on magnetic materials, in order to obtain data which will be valuable in the design of plate and filament transformers and reactors.

THE VERY HIGH TEMPERATURES that are expected to be encountered in aircraft and missiles are presenting unusual problems to the designers of electronic equipment and components. Two solutions that have been suggested are (1) to introduce more cooling capacity to maintain the equipment at a safe maximum operating temperature, and (2) to use parts and processes that are inherently temperature tolerant over a wide temperature range. If the latter approach is taken, the component designer must make a major development contribution to extend successfully the ambient temperature rating of his device from a present day 200 C maximum to a value expected to be as high as 500 C.

Fig. 1. Group of EI punched lamination (1-inch center leg width) magnetic test specimens mounted in place for elevated temperature tests.

The U. S. Air Force is sponsoring the development of electronic power transformers that will be capable of withstanding a 500 C ambient temperature as well as the other adverse environments to which military equipment is normally exposed. One important material used in transformers and for which the designer requires exact knowledge is the iron core. It is known to have temperature-dependent properties. The purpose of this article is to describe the experimental work performed as one phase of the development to determine quantitatively the effect of temperature on magnetic materials. Properties pertinent to power transformers are core loss, excitation, and incremental permeability. These were measured on a grain-oriented silicon iron at several flux densities and at four different temperatures up to 550 C, to obtain basic data that are expected to be useful in the design of plate and filament transformers and reactors.

MATERIALS SURVEY

FIVE GENERAL TYPES of steels are known to retain their magnetic characteristics at temperatures as high as 600 C. These are low-carbon steel, powdered iron, silicon steel, grain-oriented silicon steel, and cobalt iron. Of these, grain-oriented silicon steel was selected for evaluation because of its well-known superior performance for normal commercial and military applications, its availability and low cost, and its long-accumulated processing background. Although cobalt iron surpasses it in Curie temperature (740 C as opposed to 900 C) and in room temperature saturation flux density (15 kilogausses as opposed to 20 kilogausses), it is 20 times as costly and has uncertain processing problems associated with it.

The complete designation of the silicon steel evaluated is AISI-M6 grain-oriented 3¼% silicon steel. A 0.010-inch thickness was used because of the contemplated 400 cycle per second (cps) frequency application. The material was supplied in strip form with a thin film of high-temperature insulative coating on each side. It was then punched into the desired shape and given a standard 1,115 C pure dry hydrogen anneal.

TEST CONDITIONS

Properties Measured. Exciting current and core loss, fundamental indications of the condition of magnetic materials, were measured at 400-cps frequency as a

Full text of paper 58-209, "An Experimental Study of Magnetic Materials for Use in Ultrahigh Temperature Electronic Transformers," recommended by the AIEE Electronics Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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The author wishes to acknowledge the support of the work reported in this article by Air Force Contract No. AF33(616)-3625 through its project engineer, J. F. Rippin, Jr.; the design of the test specimens and the performance of the tests by R. S. Russell; and the counsel and guidance of D. E. Bovey

function of flux density at four different temperatures: 30 C, 250 C, 400 C, and 550 C. Measurements were made approximately 4 hours after exposure to the desired temperature. Data suitable for use in the design of reactors were also obtained at these four temperatures and at three a-c flux density values: 25, 1,000, and 5,000 gausses. Aging tests were made in addition to the short time tests to determine the effect of exposure of the material to a 550 C temperature for 1,000 hours. The effect was measured by observing the core loss and excitation, initially, at 300 hours, at 600 hours, and at 1,000 hours.

Test Specimens. The 0.010-inch grain-oriented strip material was punched into several sizes of UI and EI lamination shapes. These were then stacked into coils specially designed for each size. A stack height of approximately 1½ times the leg width was used. The coils were of standard construction. The sheet and spool insulation was composed of mica paper, and a glass fiber was used for the wire insulation. The secondary winding was wound on first and the primary on top of it. The wire for the secondary in all samples was 0.0126-inch nickel-clad copper; the largest diameter aluminum wire that could be fitted into the space available for the coil was used for the primary. In this way, the coil copper losses were maintained at a negligible value. The leads were made long enough to pass through the test furnace door to eliminate junction point problems. Six samples of each core size with their associated coils were evaluated. Representative specimens in place for the elevated temperature tests are shown in Fig. 1. The number of samples was reduced to two and to a single lamination size for the reactor design data tests. Lamination sizes for the core loss and excitation tests covered the width range for the major leg from ⅜ to 1½ inches in ⅛-inch increments.

Test Procedure. Core-loss and exciting-current data were obtained with the use of the circuit in Fig. 2. The flux density was controlled with the input voltage. The induced voltage from which the flux density was calculated was measured with a calibrated rectifier voltmeter placed across the secondary leads. At each flux-density setting, the input current, watts, and output voltage were read. Six to eight flux-density settings were used for each core over a range of 20 to 110 kilolines per square inch. Data obtained in this manner were analyzed and plotted as core loss in watts per pound and excitation in ampere-turns per inch as a function of flux density and temperature.

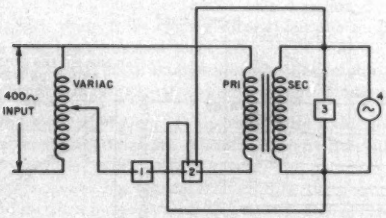

Fig. 2. Test circuit for core loss and excitation tests. Instruments are (1) thermocouple ammeter, (2) light beam wattmeter, (3) rectifier voltmeter, and (4) oscilloscope.

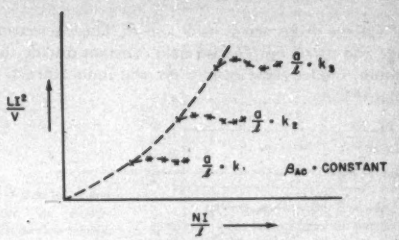

Fig. 3. Typical reactor design curve.

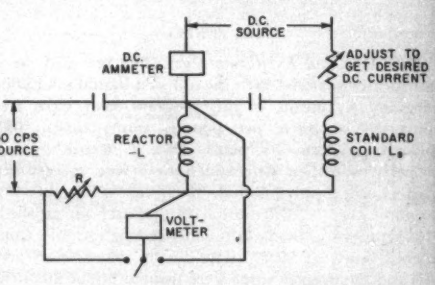

Fig. 4. Test circuit for reactor design data tests.

Data suitable for the design of reactors are usually plotted[1] as LI^2/V vs NI/l, where

L = inductance, henries
I = d-c current flowing in the reactor circuit, amperes
V = core volume, cubic centimeters
N = number of reactor coil turns
l = mean length of magnetic circuit, centimeters

Two parameters are a-c flux density and the ratio of air gap to mean length of magnetic circuit a/l, where

a = total air gap length, centimeters

Data are obtained for a given air gap ratio and a-c flux density by varying the d-c current. The larger the air gap ratio, the higher the d-c current (NI/l) required to reach a maximum LI^2/V. Fig. 3 illustrates the type of raw data obtained. The envelope of the individual curves is then drawn (the dashed curve in Fig. 3) and transverse marks placed on it at the tangent points to locate specific a/l values. It is this latter curve that is used for the design of reactors.

The circuit used to obtain the reactor design data is shown in Fig. 4. In this circuit, R is adjusted to give

equal voltage drops across itself and L. The alternating voltage and direct current are held constant during this operation. Under these conditions, the inductance L is calculated from

$$L = \frac{L_a R}{2\pi f L_a - R}$$

where

L = unknown inductance, henries
L_a = known air core inductance, henries
f = a-c applied frequency
R = measured value of resistance, ohms

With L now known, the curves in Fig. 3 can be plotted.

DATA ANALYSIS

Core Loss and Excitation Data. The raw data were statistically analyzed with the aid of a digital computer program. By means of this program, they were first converted to watts per pound, ampere-turns, and flux density. A curve of best fit for a given core size and property was then determined by trying successively higher order polynominal equations until the 5% point of the "F distribution test" could be satisfied. Flux density was used as the independent variable. Confidence limits at 99.9% were finally determined, and this and the average value were printed out at flux-density points from 30 through 110 kilolines per square inch at intervals of 10 kilolines per square inch.

The core loss and excitation data as read from the computer program are plotted in Figs. 5 and 6 as a function of temperature with flux density as an adjustable parameter for particular UI lamination shape leg widths. The ¾-inch width selected fitted approximately midway in the size range tested. Further analysis showed that data from the other lamination sizes were similar to these although displaced in an orderly pattern depending on size and, in the case of the excitation, on the flux density. Simple correction factors, therefore, make the one set of data applicable for all the other sizes. These correction factors have been included in the curves of Figs. 5 and 6.

Reactor Design Data. These data were plotted according to the scheme illustrated in Fig. 3 for each of the two samples. The average envelope curve was then drawn for each a-c flux density and temperature condition. The analyzed data are plotted in Figs. 7 through 9. Each graph is for a different a-c flux density while temperature is used for the parameter. The transverse gap ratio marks as used in Fig. 3 have been omitted. They have been replaced by a new curve, Fig. 10, of a/l vs NI/l, which is a more accurate and a simpler way of determining the air gap required for a given d-c current bias.

DATA INTERPRETATION

Core Loss and Excitation. The data reflect three major changes[2] that occur in magnetic steel when the temperature is increased. These are:

1. The electrical resistivity increases. This gives rise to lower eddy currents and, so, a lower core loss.
2. Within the saturation limits of the material, the permeability increases. The lower excitation values at approximately 50 kilolines per square inch induction and smaller, shown in Fig. 6, are a direct outcome.
3. The flux density value at which the material becomes saturated gradually decreases until at the Curie temperature, approximately 740 C for silicon steel, it is totally nonmagnetic. The substantially higher excitation values at 50 kilolines per square inch induction and greater in Fig. 6 emphasize this tendency.

The core loss at 550 C is reduced to about 60% of its room temperature value for each of the lamination shapes considered. According to the data, this per-cent change is not a function of flux density. Lamination

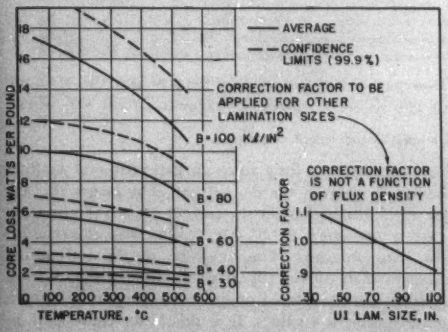

Fig. 5. Core loss as a function of temperature and flux density for UI laminations, stacked in an interleaved alternate groups-of-four arrangement.

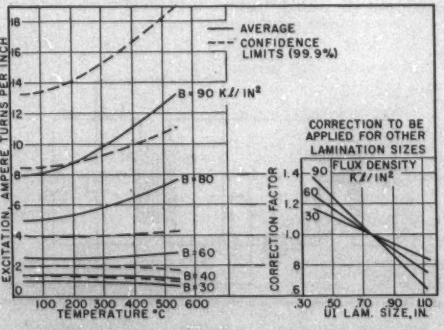

Fig. 6. Excitation as a function of temperature and flux density for UI laminations, stacked in an interleaved alternate groups-of-four arrangement.

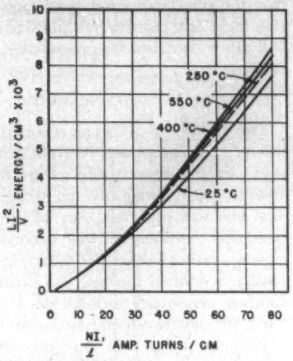

Fig. 7. Reactor design curves for 25-gauss a-c flux density.

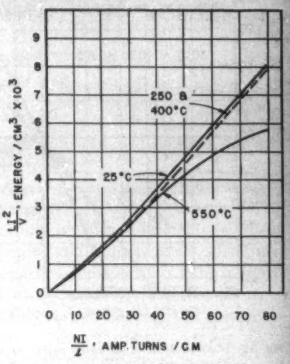

Fig. 9. Reactor design curves for 5,000-gauss a-c flux density.

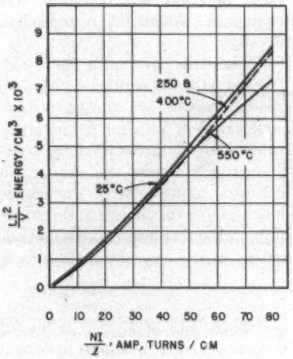

Fig. 8. Reactor design curves for 1,000-gauss a-c flux density.

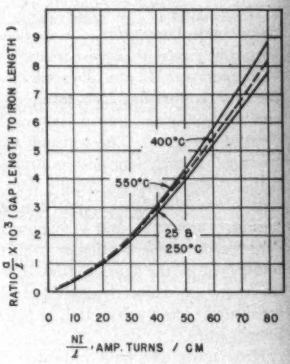

Fig. 10. Curves to determine gap length for reactor designs. Data are applicable for any a-c flux density up to 5,000 gausses.

size, however, is a variable, with the losses per pound decreasing as size or weight is increased.

The excitation requirements at 550 C, on the other hand, are a function of flux density. They are 75% of those required at room temperature for 30 kilolines per square inch induction and increase to approximately 200% at 100 kilolines per square inch. The flux density, for which there is no change throughout the temperature range, is estimated to be between 50 and 60 kilolines per square inch. Lamination size is a variable with the excitation decreasing as size or weight is increased.

Reactor Design Data. Temperature and induction effects on the material are reflected in these data in the same manner as was observed with the core loss and excitation data. For a given temperature, the permeability of the iron increases with flux density to a maximum until saturation starts setting in. Thereafter, the permeability slowly drops off to zero. Superimposed is the effect of temperature, which produces higher permeabilities at the low flux densities but causes saturation to occur sooner, thus causing correspondingly lower permeability values to take place at the high flux densities.

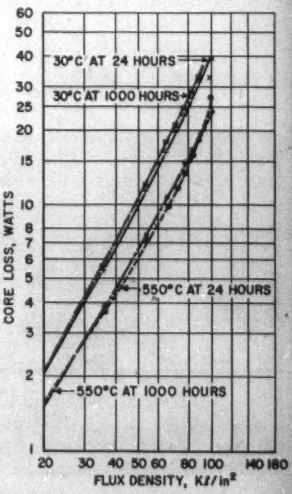

Fig. 11. Effect of 1,000-hour aging period on core loss for 13/16-inch leg width UI punched laminated stack.

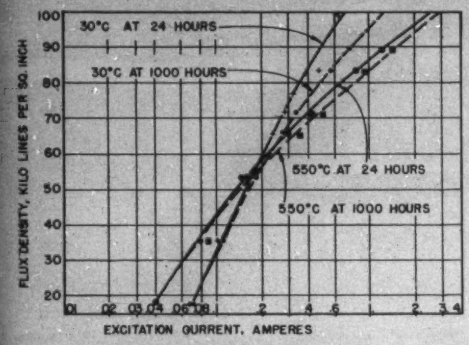
30°C AT 24 HOURS
30°C AT 1000 HOURS
550°C AT 24 HOURS
550°C AT 1000 HOURS
FLUX DENSITY, KILO LINES PER SQ. INCH
EXCITATION CURRENT, AMPERES

Fig. 12. Effect of 1,000-hour aging period on excitation for 13/16-inch leg width UI punched laminated stack.

Heat Aging Results. Heat aging tests were performed on a single lamination size to determine the effect of long-time exposure, approximately 1,000 hours, to a 550 C temperature. It was observed in one of the tests that the interlamination insulation, as evidenced by large core loss increases, had deteriorated within an elapsed time of 200 hours. The addition of a second insulation coating on each lamination produced satisfactory results, as demonstrated by the core loss and excitation data plotted in Figs. 11 and 12 at 30 C and 550 C temperatures and at 24- and 1,000-hour time exposures. The core loss for these particular conditions was essentially unaffected by the aging period. The excitation current, however, experienced small permanent changes that amounted to as much as 15% at 550 C and 30% at room temperature.

Heat aging tests have indicated the very critical role that the interlamination insulation plays. The separation must be a positive one and free from any voids that will allow oxidation to progress between adjacent laminations.

CONCLUSIONS

THE EXPERIMENTAL WORK reported here indicates that the magnetic properties of grain oriented 3¼% silicon steel are significantly affected by temperature. In the 30 C to 550 C range investigated, a 60% reduction in core loss was observed. For identical conditions, the excitation requirements were decreased or remained the same up to 60 kilolines per square inch. Above that flux density, a gradual increase was experienced that at 100 kilolines per square inch at 550 C reached as high as 200% of the corresponding room temperature value. The reactor design data were affected in much the same way, with a marked change in inductance occurring for NI/l values greater than 50 as the 30 C to 550 C temperature range was traversed. The direction of this change was found to be dependent upon the a-c flux density.

These data have value for the designer who is confronted with the problem of designing small electronic power transformers and inductors for operation in a wide range of ambient temperatures. Possible revisions in his design practice that are a direct outcome of this knowledge include the use of lower operating flux densities, adjustment of the temperature rise to take into account the change and redistribution of the losses in both the core and coil, and a compromise on the gap setting in the case of an inductor application.

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Vehicle for New Era Multiple Travel Needs

The "Astral," a new-idea craft, was created by the styling department of the Studebaker-Packard Corporation (S-P) as an idea project designed to create new approaches to automotive styling influenced by the space age. Such projects aid automotive stylists in creating new design features which may be adaptable to production models, S-P stylists said.

The graceful arm at the rear of the "Astral" is called the "Astropod" and was designed as a power receiver taking beams of ionic or nuclear force and converting them to jet thrust. S-P stylists say that the space age presents a new challenge to automotive stylists. As a possible solution to future highway problems, it could also be able to travel through the air at restricted flight levels, hover like a helicopter, and be equally at home in water.

Cell Construction for Current Limiting Reactors

L. E. SAUER
MEMBER AIEE

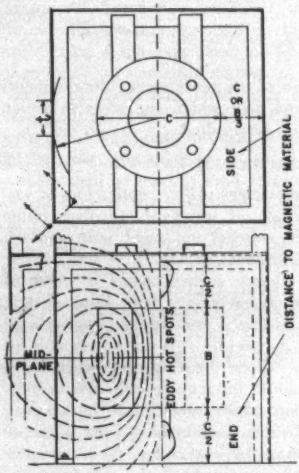

Fig. 1. Three-cell vertical arrangement: short-circuited framing.

FOR MANY YEARS, current-limiting reactor manufacturers have been showing on outline drawings dimensions for distance to magnetic materials. Instruction leaflets define magnetic materials as ". . . I-beams, channels, plates, and other steel structures hidden or exposed. Steel reinforcing rods not over ¾ inch in diameter which do not form a complete electric circuit are not considered magnetic material." Warning is given that conducting loops which enclose flux act as the short-circuited secondary winding of a transformer. The clearances to magnetic materials shown in Fig. 1 are sufficient to keep magnetic saturation losses low enough so parts will not exceed 30 C rise. However, clearances do not permit constructing the cell to form a closed circuit about the reactor; nor are they great enough to permit use of high conductivity metals. The construction in Fig. 1 of an all-metal cell is not recommended unless the coils are magnetically shielded. Consider a 5%, 400 ampere feeder reactor having 40 turns of conductor placed in such a cell. From Fig. 2, we can approximate wall currents in the cell. For 20 times normal current, the coil would develop 400 x 40 x 20 = 320,000 ampere turns plus the possibility that the first half cycle would be fully offset to increase the ampere turns to 512,000 rms. For W/d = 2 we find the current in the cell wall will be 6.4% for aluminum (32,700 amperes); 2.4% for 11 microhm magnetic steel, 3,200 amperes per sq. in. (12,300 amperes); 0.66% for 70 microhm nonmagnetic metal (3,400 amperes). The aluminum cell would probably be blown open. The magnetic and nonmagnetic steel cells might also be opened, depending on how many and how tightly the bolts were drawn up that fasten the side sheets to the framing. At normal reactor current, the aluminum cell wall would have 6.4% of normal ampere turns (1,024 amperes); the current density in the magnetic steel would make its ampere turns the same as the 70 microhm nonmagnetic 0.66% (106 amperes). None of the foregoing cells would have excessive heating at normal current but, under fault conditions, they might prove to be dangerous. Insulated joint or magnetic shielded construction should be used.

When insulated joint construction is used, it is recommended that at least two be provided in each loop. Single insulated joints are too susceptible to "sneak short-circuiting" by other construction, or changes during field erection. Heat and noise of short-circuited loops are not always evident under normal current conditions to warn of danger during fault conditions. Heating at normal current, which is caused by magnetic losses, is just a power loss but one must be sure it is magnetic loss and not short-circuited structure.

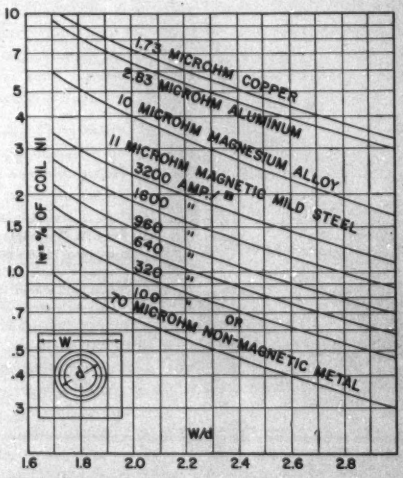

Fig. 2. Mutual induced current in short-circuited bands of different materials. I_w = current in 2 inch x ⅛ inch band. NI = coil ampere turns.

Digest of paper 58-46, recommended by the AIEE Transformers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Application of Vacuum Switches to Utility Loads

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Vacuum switches have had an excellent performance record in applications to which they have been assigned. However, because of their rapid development and acceptance, numerous questions and misconceptions about them have arisen. An attempt is made to provide information which will help to overcome this problem.

THE SPEED with which the vacuum switch has received acceptance throughout the electric utility industry has produced a rather formidable education problem. This problem is not simplified by the fact that the vacuum switch development program, so far as utility applications are concerned, also has progressed with great rapidity.

The combination of these two fast-moving trends has made it virtually impossible for vacuum switch manufacturers to supply the entire utility industry with complete and current information regarding the detailed aspects of vacuum interrupter applications in electric utility systems.

In this article, an attempt will be made to clarify a few of the misunderstandings that seem to have arisen and to suggest some of the more recent developments which, it is expected, will widen the areas in which vacuum switches may be applied.

Fig. 1. One phase of a typical 115-kv 600-ampere gang switch equipped with a vacuum interrupter unit.

VACUUM SWITCH RATINGS

SINCE THE MOST PUBLICIZED utility applications of vacuum switches have almost invariably involved gang-operated disconnect switches equipped with vacuum interrupters, such as shown in Fig. 1, it has become quite common for electric utility people to think of vacuum interrupters as having the same kind of rigid voltage and current ratings as are customarily associated with gang switches. As a result, it is not uncommon for a potential user to express great surprise when he is informed that a vacuum interrupter unit designed for use at a given voltage level (for example, 69 kv) may consist of as few as three vacuum breaks per phase or as many as six per phase. In other words, the interrupter may contain anything from three to six sets of vacuum contacts in series on each phase.

This seemingly contradictory situation arises directly from a simple requirement that must be satisfied in the design of any kind of a load interrupting device, i.e., the requirement that the dielectric recovery rate of the interrupter must exceed the voltage recovery rate at the particular location of the switch installation.

This requirement, in the case of vacuum interrupters, can be met only after one has a complete knowledge of the dielectric recovery behavior of the particular vacuum switches which are to be cascaded as series elements in the ultimate vacuum interrupter unit.

Having such a knowledge, the designer can couple this information with a knowledge of the anticipated voltage recovery rate to which the switch will be subjected. He can then determine, with complete reliability, how many sets of vacuum contacts must be cascaded in series on each phase of the interrupter unit.

Fig. 2[1] represents the ability of the Jennings type *R9G* vacuum switch to withstand recovery voltage under various current conditions. It also represents life expectancy for this vacuum switch.

From this figure it can be seen (long-dashed curve) that a single type *R9G* vacuum switch will withstand a recovery voltage of approximately 33 kv peak immediately after interrupting a 250-ampere load. Each type

Full text of a paper presented at the American Power Conference, sponsored by the Illinois Institute of Technology, Chicago, Ill., March 26-28, 1958.

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R9G switch in a cascaded series of two or more (solid curve) will withstand a recovery voltage of approximately 38 kv peak immediately after such an interruption. This means that three type *R9G* switches cascaded in series will have a total recovery-voltage-withstand rating of three times 38 or 114 kv peak immediately after a 250-ampere interruption.

From the dotted curve in Fig. 2, it can be seen that the vacuum switches involved in the preceding cases would have a life expectancy of approximately 5,000 operations if all interruptions were at 250 amperes.

From the preceding facts, it is apparent that the rating information for a vacuum interrupter unit can be rigidly defined only in terms of the curves of Fig. 2. Furthermore, the decision as to how many vacuum switches shall be used in each phase of the interrupter unit must necessarily take into consideration more than the performance capabilities of the switch equipment itself. This facet of the problem can best be illustrated with a specific case.

Let it be assumed that it is desired to switch a 10,000-kvar Y-connected capacitor bank on a 115-kv system. The problem is to determine how many vacuum switches must be cascaded in series on each phase of the interrupter unit.

Capacitor Bank Y-Connected with Neutral Grounded on a Grounded-Neutral System. In this case, the steady current which the switch will be called upon to interrupt is approximately 50 amperes. It is a foregone conclusion that more than one vacuum switch will be required on each phase of the interrupter; therefore, the solid curve of Fig. 2 will be used. From this curve, it is apparent that the individual vacuum switches in the cascaded series will have an ability to withstand approximately 50 kv crest.

Both experimental and analytical studies have reliably established the nature and magnitude of recovery voltages which can be anticipated in a case such as the one being studied.[2, 3] In this instance, the recovery voltage will have a crest value of twice the peak line-to-neutral voltage of the system, or approximately 188 kv.

From these facts, it follows directly that the vacuum interrupter unit must consist of at least four vacuum switches in series on each phase.

Capacitor Bank Y-Connected with Neutral Ungrounded on a Grounded-Neutral System. In this instance, the sequence in which the three phases of the switch interrupt will determine the magnitude of the recovery voltage. If the sequence is the same as the phase sequence of the system voltage (for example, first phase *A* opens and interrupts, then phase *B* opens and interrupts, and finally phase *C* opens and interrupts), the recovery voltage will reach a crest value of 4.1 times the peak value of line-to-neutral voltage, or approximately 384 kv.

If the three phases of the switch interrupt their loads in the negative of system voltage phase sequence (that is, *A*, *C*, *B*), the crest value of the recovery voltage will

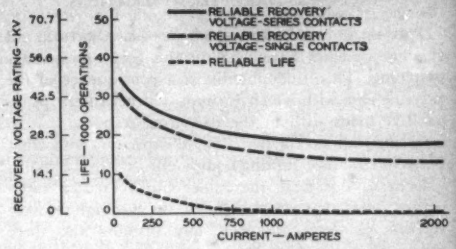

Fig. 2. Curves showing ability of Jennings type *R9G* vacuum switches to withstand recovery voltage under various load conditions, and also showing reliable life expectancy data.

be only 3.47 times the peak value of line-to-neutral voltage, or approximately 325 kv.

It is apparent now that if the three phases of the vacuum interrupter are adjusted to drop their respective loads in the *A*, *B*, *C* sequence, a minimum of eight vacuum switches must be cascaded in series on each phase of the switch. On the other hand, if the switch is adjusted for *A*, *C*, *B* interrupting sequence, then only seven vacuum switches will be needed on each phase.

Capacitor Bank Is Increased in Size. The effect of increasing the size of the capacitor bank is to reduce the ability of the vacuum switches in a cascaded series to withstand recovery voltage. As a ridiculous extreme, let it be assumed that the capacitor bank is increased to 50,000 kvar, thereby establishing a steady current value of 250 amperes.

From the solid curve in Fig. 2, it can be seen that this reduces the recovery-voltage-withstand rating of the vacuum switches from 50 kv to about 38 kv; so the required number of vacuum switches on each phase must be increased in the ratio of approximately 5 to 3.8. To effect such an increase in many cases would produce unwieldly mechanical systems.

Life Expectancy. In the case of a 10,000-kvar 115-kv capacitor bank, the dotted curve of Fig. 2 indicates that the vacuum interrupter would have a life expectancy of 10,000 operations. In the extreme case of a 50,000-kvar 115-kv capacity bank, life expectancy would drop to approximately 5,000 operations.

From the foregoing illustrative examples, it should be clear that a vacuum interrupter intended for one application on a 115-kv system should not be expected to be identical to one which is intended for a different application on that same system. Furthermore, it should be clear that an inherent part of the rating information on any vacuum interrupter is life expectancy data.

It should be equally apparent that in applications in which the recovery voltages are small (for example, load interrupting applications involving essentially unity power factor loads), both the size and the cost of a vacuum interrupter in a given voltage class will be minimum.

VACUUM INTERRUPTER APPLICATIONS

PROBABLY THE MOST EXTENSIVE APPLICATIONS of vacuum switches have been in the field of capacitor switching. This, undoubtedly, is a consequence of the extreme ease with which vacuum switches interrupt capacitive loads without the damaging restrikes that so frequently attend the switching of capacitors with other kinds of load-interrupting equipment.

Even in this field, the rather bulky vacuum interrupter units that were required by the high-recovery voltages generated by randomly opening the three phases of a capacitor bank supply line caused many people to reject this type of switch equipment. To cope with this problem, switches have been developed to provide for a specific sequence of phase openings, and several capacitor banks of the ungrounded-Y type are currently being switched with vacuum interrupters that are adjusted for the optimum *A*, *C*, *B* sequence of phase openings.

An even more reliable and economical approach to this problem is the recent introduction to the industry of automatic neutral grounding equipment which, through an electrical interlocking system, momentarily grounds the neutral of an otherwise ungrounded capacitor bank during the short interval in which the main vacuum switch is isolating the capacitor bank from its source.

This development makes possible the switching of any Y-connected capacitor bank, on a grounded neutral system, as though its neutral were grounded. In other words, this system permits the smallest and the most economical switching equipment possible for switching ungrounded-Y-connected capacitor banks.

Fig. 3 shows a 10,000-kvar 115-kv Y-connected ungrounded-neutral capacitor bank which has been switched by means of a combination of an electrically interlocked vacuum switch and a neutral grounding switch for many months.

Fig. 3. Capacitor bank on Louisiana Power and Light Company system, using electrically interlocked vacuum switch and momentary neutral grounding switch.

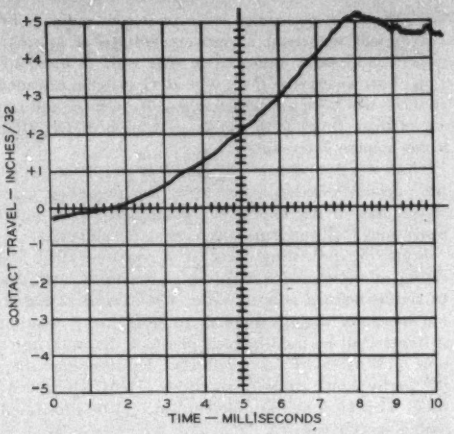

Fig. 4. Oscillographically produced curve showing position of vacuum interrupter contact vs time as moving contact moves away from the stationary contact.

Previous publications on the subject of vacuum switch applications[4, 5, 6] have rather thoroughly presented discussions of the more conventional types of switching problems to which the vacuum interrupter is ideally suited. They quite clearly evidence the optimism which has always been felt regarding the interrupting ability of vacuum switches on all kinds of loads having leading power factors, or having lagging power factors to as low as 0.85. This, of course, includes all such applications as line dropping, unloaded-cable dropping, industrial-load dropping, etc.

Throughout many of the early publications, however, there ran a cautious pessimism regarding the transient voltages that might be generated by the wave-chopping characteristics of the vacuum switch in the low power factor regions. This justifiably produced serious doubt as to the ability of the vacuum switch to interrupt transformer magnetizing currents without producing transient voltages serious enough to cause potential damage to the transformer itself.

It was predicted that "as additional testing proceeds and as more is learned about the exact mechanism of interruption in a-c cases, this need for caution probably will be eliminated."[6]

A recent publication[1] does, indeed, justify this earlier optimistic prediction. It points out, for example, that "By use of the proper contact opening speed of under one foot per second at the initial opening, increasing to five feet per second at a sine wave rate a great deal of the possible current zero choppings can be eliminated."

The implication here is obvious. By properly designing vacuum switch actuators to produce sinusoidally varying contact separation velocities having the desired speed range, it is now quite practicable to switch transformer magnetizing currents with vacuum interrupters.

The feasibility of producing such actuators is evidenced by the oscillographically produced curve of Fig. 4. This curve represents the position of the moving contact, in a vacuum switch, versus time from the position of "contacts closed" to "contacts fully open." The projection of the curve below the zero position axis is indicative of the over-travel of the contact pressure producing system. The curve demonstrates the feasibility of achieving sinusoidally distributed contact velocities within the speed ranges required for successful switching of such low lagging power factor currents as transformer magnetizing currents.

From this illustration, it can be seen that the contact speeds stipulated previously can readily be attained by the system which produced this curve, and any deviations (from the optimum) that are evidenced by this curve can be corrected quite simply.

This means that the de-energizing of very large high-voltage transformers can now be accomplished with vacuum interrupters, which represent tremendously reduced investments when they are compared with the oil switches that previously had to be employed for this purpose.

Previous publications on the subject of vacuum switches spoke with some pessimism regarding the economic feasibility of producing vacuum interrupters that could compete with the horn-fiber type load-interrupting equipment. Recent developments have demonstrated that even this early pessimism was, perhaps, exaggerated.

Present indications are that so-called light-duty vacuum interrupters as direct competitors with horn-fiber interrupting devices are just around the corner. The performance capabilities of such light-duty vacuum interrupters will undoubtedly dwarf those of the gas-emitting horn-fiber equipment.

The advent of such inexpensive vacuum interrupter equipment undoubtedly presages the rapid development of a complete new field of applicability for vacuum switching equipment.

CONCLUSIONS

THE EXCELLENT PERFORMANCE RECORD which vacuum interrupters have produced in every application to which they have been assigned has established for them a reputation for reliability and economy. Such success can breed only further confidence and ultimate expansion of vacuum interrupter applications throughout the utility industry.

The short-circuiting of current limiting reactors in major generating station busses, the interruption of differential faults on large transformers, and the widespread performance of line-sectionalizing duty are but a few of the new fields of application into which the vacuum interrupter has already started to move.

With the developments of higher momentary current capabilities and higher interrupting capacities that are presently in process, there is every reason to expect that the invasion of the vacuum interrupter into the utility switching picture will progress at an even more rapid pace in the next few years than it has in the past.

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Electronic Typing Calculator

The Electric Typewriter Division of the International Business Machines Corporation (IBM) recently announced the IBM *632* electronic typing calculator, designed primarily for invoice and order preparation, the heart of the accounts receivable operation in thousands of businesses. Simplicity and ease of training operators are two important advantages. A typist can operate the computer with only a few minutes of instruction.

The calculator consists of an electric typewriter, a 10-key companion keyboard. a magnetic core "memory" within the computer unit, and a program reading device. The IBM *632* can automatically type, extend, carry totals, compute taxes, subtract discounts, position decimals, justify multidigit numbers, and type out results.

Automatic Telegraph Switching System Plan 55-A

G. S. VERNAM
MEMBER AIEE

A fully automatic, world-wide switching system is being engineered by Western Union for the United States Air Force to meet the need for rapid and secure transmission of large volumes of military traffic over a world-wide network.

IN ORDER TO MEET the needs of the U. S. Air Force for rapid and secure transmission of very large volumes of military traffic over a world-wide network, a switching system should meet the following requirements.

1. It should provide for rapid automatic switching of messages through any number of switching centers without operating attention.
2. Where defects in a message or trouble conditions prevent automatic switching, means should be available for immediate manual (push button) switching of messages to avoid delay.
3. The switching system must be compatible in operation with the equipment used by the other military services, so that messages can be relayed from one service to another without manual retyping. Obviously, the switching system must also be compatible with any other message relaying system in use by the Air Force.
4. The switching equipment must be capable of either automatically or manually switching multiple-address messages.
5. The equipment should be designed on the "building block" principle, with the minimum number of different types of cabinets, each complete in itself, with plug-in connections to the other cabinets arranged for quick installation or removal.
6. Fast handling of all traffic, but with preference in switching being given to messages of high precedence, is essential.

Fig. 1. Plan 55-A prototype set up for test.

The Plan 55-A system (Fig. 1), developed by The Western Union Telegraph Co. to meet these requirements, consists of a number of reperforator switching centers interconnected by trunk lines, with lines radiating from each center to tributary stations in the area served by that center. Messages originated at any tributary station are relayed automatically through one or more switching centers to their destinations at other tributary stations. This system can be operated over wire lines or radio channels and can be expanded beyond national and continental boundaries. A Plan 55-A switching center can exchange traffic with switching centers using other types of switching equipment, including Plan 51 reperforator switching or semiautomatic ("torn tape") relaying equipment.

In Plan 55-A switching centers, messages are received and retransmitted automatically in the form of perforated tape. Routing is controlled by "routing indicators" (normally groups of six letters) recorded in the tape as part of the heading of each message. The form of message conforms to standards agreed upon among the armed services and the switching equipment has been designed to be compatible in operation with the equipment used by the other military services.

MESSAGE SECURITY

NUMEROUS SAFEGUARDS and alarms are provided throughout the system to prevent errors, avoid delays, and guard against lost messages. Each message is numbered in sequence as transmitted to an outgoing line or channel and these channel numbers are automatically checked as the messages are relayed. For this purpose, automatic message-numbering machines are provided to transmit the office call, channel designation, and serial number ahead of each message. For each incoming circuit, a number comparator device, known as a "sequence-number indicator" (SNI), is provided to check

Revised text of paper 58-45, recommended by the AIEE Telegraph Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y. Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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the numbers automatically. The SNI is similar in design to the automatic numbering machine and is shown in Fig. 2. It is contemplated that some messages will be transmitted in code or cipher. As this cryptographic equipment is not part of the Plan 55-A switching equipment, it is not discussed in detail.

Fig. 2. Sequence number indicator.

MESSAGE PRECEDENCE

MESSAGES ARE TRANSMITTED from the office of origin in order of precedence and are delivered at their destinations in the same order. There are six precedence classifications designated in the message by repeated characters called "precedence prosigns." For switching purposes, the first three precedence classifications are normally considered as "high precedence" and the last three as "low precedence." High precedence messages are given preference in switching.

MESSAGE TRANSIT THROUGH SWITCHING CENTERS

THE TRANSMISSION of a single-address message from origin to destination, through two switching centers, is illustrated in Fig. 3. At each switching center, the message is perforated and transmitted twice. The first reperforation is at a receiving or incoming line position. The message is then switched and transmitted "across office" to a sending or outgoing line position where it is reperforated and transmitted again. The form of the message, at each stage, is shown in the drawing. As transmitted from the office of origin and recorded by the printer–perforator at the first switching center, the start-of-message (SOM) characters ZCZC and the message serial number are followed by the precedence prosigns and routing indicator, or indicators, the text of the message and the end-of-message (EOM) characters LF NNNN.

The characters of the incoming message channel number are checked by the SNI before the message is switched. Checking each message serial number as it appears in the tape prevents loss of messages, facilitates identification of messages for reruns, and also serves as a periodic transmission check. In case of a wrong number comparison, transmission is stopped immediately and supervisory alarm signals are actuated. As this occurs before the message has been switched and transmission across office has not started, it is not necessary to send a cancellation notice.

As described later, the transmitter at the receiving position is designed so that it can step through and read the precedence characters and routing indicators twice; first, for switching control and, second, to transmit them across office. After the first passage through the transmitter, indicated route connections are set up by switches in the receiving position, but actual cross-office line connections are not established until the EOM characters are received, except that in the case of "flash" or "emergency" messages, such connections are established immediately.

When the cross-office connection is set up, a new outgoing channel number is recorded in the tape at the sending position, transmitted from the automatic numbering machine. The incoming channel number is then transmitted across office by the SNI and the text and EOM characters are sent by the transmitter. After the EOM characters, the cross-office circuit is disconnected.

From the sending position, the message may be sent to a tributary of the same switching center, but in most cases the message will be switched through at least two centers. The message, as received at the second center, now has two serial numbers, an outgoing channel number and an incoming channel number. The operations involved in transmitting the message through the second center are the same as those described for the first center, except that after the first number is checked by the SNI, the second number steps through the transmitter and is discarded. A new outgoing channel number is added at the head of the message by the numbering machine. Only two channel numbers are carried along with the message as it is relayed from center to center, thus providing adequate identification while conserving line time.

MULTIPLE-ADDRESS MESSAGES

MULTIPLE-ADDRESS MESSAGES are recognized as such by the presence of more than one routing indicator. Each routing indicator is preceded by a space character and the last routing indicator is followed by a carriage return character. All routing indicators are printed in one line and the number of routing indicators in a message is limited to nine. Multiple-address messages are automatically processed in order to transmit an individual copy of the message to each ultimate destination. In this process, the routing indicators are segregated so that each final copy of the message contains only one routing indicator corresponding to its destination. At a switching center, several of the routing indicators in a message may require the same circuit outlet. For example, two or more routing indicators may be for tributaries of another switching center, or for more distant centers to be reached through the same intermediate switching center. Such messages are transmitted

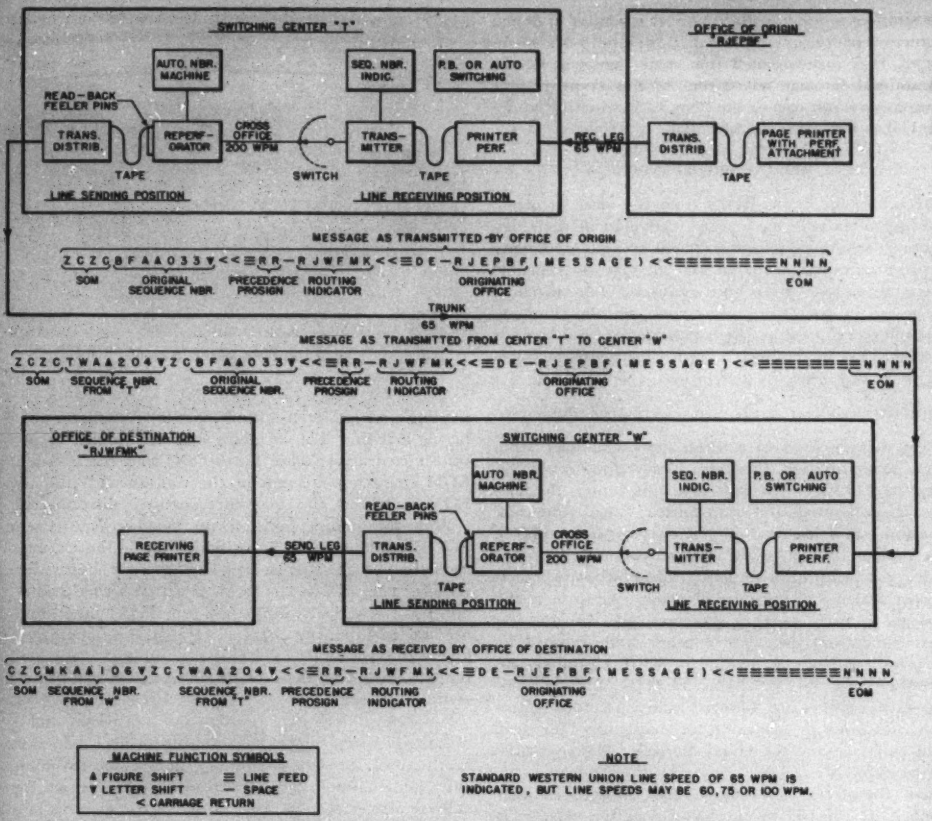

Fig. 3. Switching single-address message through two switching centers.

to the intermediate center containing only the routing indicators for which that center is responsible.

Any receiving position can switch a multiple-address message directly to four outlets—no more. As relatively few messages require switching to more than four circuit outlets, most messages can be switched directly from the receiving positions. All preliminary operations for a multiple-address message are the same as for a single-address message up to the point where the first routing indicator has been processed. The space character following the first routing indicator is identified and the transmitter is restarted to process the second routing indicator. This process continues until a carriage return character, after the last routing indicator, identifies the end of the routing line.

In relatively rare cases, a message may need to be switched to more than four circuit outlets. In such cases, all routing indicators requiring an outlet different from the first three, are sent with the message to an extra operating position assigned for this purpose. In very rare cases, a message with eight or nine routing indicators may need to be transmitted to an extra position a second time.

SWITCHING CENTER COMPONENTS

THE TWO PRINCIPAL ITEMS of equipment required in a Plan 55-A switching center are the incoming and outgoing line consoles or cabinets. Each cabinet houses two operating positions. The incoming line cabinet has a control cabinet installed behind it to provide additional mounting space for equipment. These cabinets are interconnected by cables terminated in multiconductor plugs and sockets. To meet military requirements, all cabinets of each type are alike and require no essential common equipment to set up an operable center for manual switching. The incoming and outgoing cabinets

are linked together by cross-office switching circuits over which messages are transmitted electronically at 200 wpm. Fig. 1 shows the incoming or receiving cabinets at the left and the outgoing or sending cabinets at the right side of the aisle.

These cabinets contain all the equipment needed for reperforating, transmitting and push-button switching. The "building block" principle thus obtained enables a center to be expanded or contracted as circumstances dictate with the minimum of disturbance to traffic handling. As initially equipped, each incoming line position can switch messages to a maximum of 200 circuits and 100 destinations, by providing a suitable number of outgoing line consoles. By adding switches, the equipment can be expanded to 400 circuits and 200 destinations.

A third type of equipment, a director–translator cabinet is required for automatic switching. The cabinet houses two directors and a translator. It is similar in design to the receiving cabinets and is normally installed at the end of a receiving row. The director receives routing information from the message tape and controls switching operations at the start of each message. The translator receives routing indicators from the director and translates them into switch settings. As these operations take only a few seconds, relatively few directors and translators are required. It is proposed to install them in the ratio of one director cabinet for every 25 incoming line cabinets.

RECEIVING POSITIONS

EACH RECEIVING POSITION is equipped with a type *28* printer-perforator for reproducing incoming messages in printed-perforated form. Associated with this machine is a message-waiting indicator with associated control circuits designed to detect and count bell signals (upper case S), the SOM signal ZCZC, and the EOM signal LF NNNN. The bell signals are used to detect "flash" and "emergency" messages. The EOM signal controls the message-waiting indicator (MWI), adding one on its dial for each message received. The transmitter circuit subtracts one for each complete message transmitted, so that the MWI dial indicates the number of complete messages on hand. The SOM and EOM signals are received alternately, as they occur at the start and end of each message. If the EOM signal is missing or defective, as received, there will be two successive SOM signals. The MWI circuit operates a "no EOM" alarm and blocks cross-office transmission, thus preventing a message from following through to the same destination after a preceding message with a defective EOM combination.

LOOP-GATE TRANSMITTERS

EACH RECEIVING POSITION has a "loop-gate" transmitter, shown in Fig. 4, for reading characters in the message tape and transmitting them at 200 wpm to the automatic switching director or across office to a reperforator at a sending position. Associated with the transmitter is a SNI for checking incoming message numbers, as recorded in the tape, and retransmitting them across office at the proper time. The transmitter also has associated electronic means for detecting certain characters in the tape as they pass through the transmitter. An "electronic transmitter" is also provided to transmit messages and to transmit and receive control signals across office.

The "loop gate" is a slide latch which permits sending certain portions of the message twice. With the loop gate in its right-hand position, the transmitter functions like any conventional magnet stepped transmitter. The

Fig. 4. Loop-gate transmitter for sending messages across office.

SOM characters ZCZC start the SNI which checks the call letters and message number in the tape. If the message number is correct, the transmitter steps the tape ahead until it detects a line feed (LF) character, thus stepping through and deleting any extra numbers or other extraneous characters that may appear in the tape at this point. Upon detecting the LF, the loop gate on the transmitter slides to the left, holding the tape so that it cannot pass completely through the transmitter, but can step past the sensing pins forming a loop above the transmitter. Characters fed into this loop can be transmitted a second time.

AUTOMATIC SWITCHING

FOR AUTOMATIC SWITCHING, with the loop gate at the left, a connection is obtained to a director and the precedence prosign characters and the routing indicator or indicators are transmitted to the director, which sends back switching information for setting up the cross-office connection to the desired destination. The loop gate then returns to its right-hand position, placing the original character (the first character after the line feed) over the sensing pins. The transmitter is now ready to transmit the message across office at the proper time.

MANUAL SWITCHING

FOR MANUAL SWITCHING, when the loop gate slides to the left, a "message waiting" lamp lights to call the attendant, who looks at the precedence prosign characters on the tape and depresses a "high" or "low" precedence push button, which associates the transmitter with the push-button panel, advances the prosign characters through the transmitter, extinguishes the MSG WTG lamp and lights a "switching control" lamp. The attendant now depresses a panel push button for each routing indicator and then a "start" push button to complete the manual switching operations.

ELECTRONIC CROSS-OFFICE TRANSMISSION

ELECTRONIC METHODS are used for transmitting signals across office over a single conductor. The message characters are transmitted at 200 wpm (20 characters per second). Certain control pulses are transmitted over the same cross-office line conductor, in either direction, at the rate of 60 pulses per second. As compared to other switching systems, the use of a single conductor, in this system, greatly reduces the number of cable conductors, multiconductor plugs, sockets, and switches required. For example, eight levels of a single 25-point rotary switch serve to select any one of 200 sending positions.

The electronic units consist essentially of a "pulse generator," common to the two operating positons in each cabinet, an "electronic transmitter" for each receiving position and an "electronic receiver" for each sending position. These units generate, transmit, and detect the message and control pulses that are sent across office; and, in addition, step the tape transmitter and numbering machine; detect and indicate trouble conditions; read certain message characters, as they are being transmitted at high speed; test the idle, or busy, condition of selected routes; and control the operation of other equipment, such as the sequence-number indicators, message waiting indicators, and the automatic switching directors. The pulse generator and electronic transmitters are shown at the top of Fig. 5.

Fig. 5. Receiving cabinet, rear view, with electronic units at top.

SENDING POSITIONS

EACH SENDING POSITION is equipped with a type *28* multimagnet reperforator, shown in Fig. 6, for reproducing messages received over cross-office circuits in perforated (not printed) tape form. This reperforator operates on signals received across office at 200 wpm from the loop-gate transmitter at a receiving position. The reperforator also receives signals from an automatic message numbering machine at the same sending position.

When a cross-office connection is established, the numbering machine automatically sends, into the reperforator, the SOM characters ZCZC, the station and channel designation letters, and the message number. This number is followed by the incoming channel number transmitted from the SNI at the receiving position. This latter number is always preceded by the characters ZC and followed by CR CR LF. The message is then transmitted across office by the loop-gate transmitter, first the precedence prosign characters and routing indicators from the tape loop and then the remainder of the message, including the EOM characters LF NNNN. At this point, the loop-gate transmitter stops, the numbering machine sends two blanks into the reperforator, and the cross-office circuit is released.

CHARACTER CHECKING

THE REPERFORATOR is equipped with "read-back" contacts operated by an extra set of sensing pins located five characters to the left of the punch pins. These pins read certain character groups in each message to verify the correct operation of all equipment involved in cross-office transmission. The SOM characters ZCZC from the numbering machine are the first characters checked. The appearance of this combination indicates that the local equipment of the sending position is operating properly, including the numbering machine and the reperforator. The ZC characters ahead of the incoming channel number verify the operation of the SNI and cross-office transmission. At the end of the message, when two blanks are transmitted by the numbering machines after the EOM characters, the line feed and first N are fed over the read-back pins and checked, thus verifying that the reperforator is still operating properly at the end of the message. The cross-office connection is then released.

The ZC characters must check to start cross-office transmission of the message. Failure to check prevents transmission, locks out the sending position, operates an alarm signal at the sending position, and a "reswitch" signal at the receiving position. A "number cancellation" notice is then transmitted automatically from the

receiving position. The sending position remains out of service until manually restored after the trouble is cleared. At the receiving position, an attendant sets the tape back to the start of the message. It will be automatically switched to the same destination through another sending position, if one is available, or it will be switched to an intercept position for storage until the original sending position is restored to service.

MULTICHANNEL DESTINATIONS

TO HANDLE HEAVY TRAFFIC LOADS to a particular destination, several outgoing line circuits and sending positions may be required. All sending positions in such a multichannel group represent the same destination. Any message for that destination can be switched to any sending position in the group that is available for use at the moment. The selection of a particular position is controlled by a "load distributor" circuit. This circuit gives first choice to any sending position that has a tight tape condition. During busy periods, when no position in the group has tight tape, each sending position in the group is selected in rotation as cross-office connections are established, so that the traffic is evenly divided among the channels.

TRANSMITTER–DISTRIBUTOR

EACH SENDING POSITION is equipped with a type *28* multicontact transmitter–distributor for transmitting to the outgoing line the messages that the reperforator has recorded in perforated tape form. The transmitter–distributor operates at 60 or 100 wpm.

TWO-POSITION OUTGOING LINE TERMINATION

TWO SENDING POSITIONS can be arranged to send alternately to the same outgoing line circuit. Normally, one position is used for high precedence traffic and the other for low precedence traffic. The transmitter–distributor of the low precedence position releases the line at the end of each outgoing message to allow the high precedence position to cut in, if it has a message to send. When this occurs, all high precedence messages on hand are transmitted to line before the low precedence position can seize the line again. This arrangement makes it possible to send a high precedence message to line ahead of previously stored low precedence messages.

MULTISTATION CIRCUITS (WAY WIRES)

MULTISTATION CIRCUITS extend from a switching center to two or three tributary stations. These circuits are operated duplex. Each station is equipped for selective control so that each message transmitted from the switching center is recorded only at the station to which it is directed. At each way station, messages are prepared in perforated tape form for transmission to the switching center. Only one station can send at a time. Depressing either a high precedence or a low precedence push button at a tributary station indicates, at the switching center, that a message is ready for transmission from a way station. The switching center equipment determines whether a high precedence message is indicated and, if so, invites each station in turn that has a high precedence message to send, automatically accepting high precedence messages as long as any are indicated. If there are no high precedence messages, low precedence messages are accepted in a similar manner. The invitation sequence always starts with the station following the one that has just previously transmitted a message in order to give all stations an equal opportunity to send messages within the same precedence group.

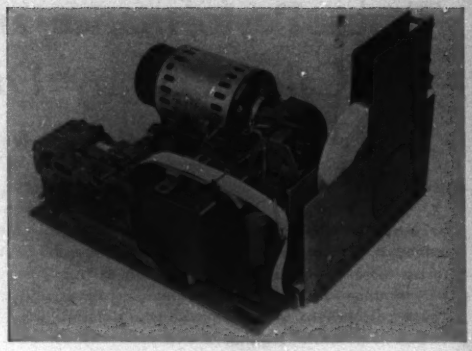

Fig. 6. Type 28 reperforator for receiving across office.

HIGH-SPEED CROSS-OFFICE TRANSMISSION

MESSAGES ARE RECEIVED over incoming lines at 60 or 100 wpm, are transmitted across office at 200 wpm and are then retransmitted to outgoing lines at 60 or 100 wpm. With the cross-office speed at least twice the speed of transmission to outgoing lines, enough message can be sent across office to any sending position to keep the outgoing line busy, while the cross-office side of that position is idle at least half of the time. It is obvious, therefore, that the receiving positions will usually obtain an immediate cross-office connection and no appreciable amount of unsent tape should accumulate at these positions. If an occasional busy condition should cause an accumulation, however, the differential between the high cross-office speed and the lower incoming line speed would transmit messages away from the receiving positions at least twice as fast as they are being received, thus rapidly reducing the tape accumulation. The line circuits can thus be operated at a very high utilization factor, without causing any appreciable traffic delay. The transmitter–distributor at a line sending position automatically functions to send continuously as long as there is any traffic at the sending position to send. Therefore, the cross-office line need only operate intermittently to provide a full outgoing circuit load.

Train Performance and Tonnage Ratings Calculated by Digital Computer

J. E. HOGAN
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Because of the considerable time savings achieved, the digital computer has been found to be advantageous in the calculation of train performance and locomotive tonnage ratings. These calculations are essential in the determination of potential purchases and utilization of locomotives and other railroad equipment, as well as investment in track improvements.

THE FUNCTION of a railroad is to provide transportation. But to be satisfactory and attractive, transportation not only must be safe and dependable, but also must be accomplished in a reasonable length of time. To accomplish this, adequate power must be applied to the trains. However, railroads cannot afford to be extravagant. Locomotives are expensive, and the bigger they are the higher the first cost and the cost of operation.

Some of the typical questions or problems arising in the purchase, selection, and assignment of locomotives and the makeup of trains are as follows:

1. How many cars or how many tons can a certain class of locomotive haul from "A" to "B" in so many hours and minutes?
2. If the time is fixed and the number of cars or tons in a train is specified, what must be the horsepower of the locomotive?
3. If cars are to be added to a train, what will be the effect on the running time?
4. With the addition or elimination of a station stop, what time changes should be made in the schedule?
5. How much time can be cut out of a schedule by eliminating a speed restriction through improvement in track conditions?
6. If time is not the governing factor, how many cars or tons can a locomotive haul at a reasonable speed on the ruling grade, or in the case of a locomotive with electric drive, without damaging the electrical apparatus by overheating?

The answers to these and other related questions may be important with respect to potential purchases and utilization of locomotives and other railroad equipment or the investment in track improvements.

Mathematical solutions have been found to be quite satisfactory in most cases. The factors involved are fairly well established, particularly in the case of electric and diesel–electric motive power. The output of such equipment can be predicted reliably.

Revised text of paper 58-190, presented at the AIEE Winter General Meeting, New York, N.Y., Feb. 2-7, 1958. Recommended for publication by the AIEE Land Transportation Committee. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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BASIC THEORY AND TERMS INVOLVED

To CALCULATE the performance of a given train over a given route, it is necessary to know the following:

1. The grades, curves, and distances.
2. The speed restrictions.
3. The weight and tractive resistance of the train.
4. The tractive force of the motive power.
5. The rate of deceleration during braking.
6. The number, location, and duration of station stops.

By tractive force is meant the total propelling force at the rims of the driving wheels. The portion of tractive force in excess of that required to overcome tractive resistance is available for producing acceleration and is known as net tractive force.

The tractive resistance may be divided into train resistance and track resistance. Several empirical equations for train resistance have been developed, generally of the type:

$$R = K_1 + K_2V + K_3V^2 \qquad (1)$$

where

R = resistance
K_1 = a term representing journal friction
K_2V = a term comprising resistances caused by flange friction, swaying, and miscellaneous frictions proportional to speed
K_3V^2 = a term giving air or wind resistance, varying as the square of the speed

The Davis formulas for train resistance are in general use in this country.[1] They were developed from tests conducted on several railroads in the 1920's. Resistance calculated by these formulas is somewhat high, however, when applied to the conditions of heavier rail, better road bed, better equipment, and the higher speeds of our railroads today.

Track resistances are the gravitational resistances caused by grades and frictional resistances caused by curves. A train moving up a grade of 1%, or 1 foot rise in 100 feet, must overcome a component of gravity equal to 20 pounds for each 2,000 pounds of train weight. Similarly, when a train moves down a grade of 1%, a component of gravity exerts a force of 20 pounds per ton to assist the movement.

A train moving on a curve is retarded by a force proportional to track curvature. For freight trains, this retarding force is usually taken to be 0.8 pound per ton of train weight per degree of curve. It may be considered as the effect of an adverse grade of 0.04% per degree of curvature. Curve resistance is much less for passenger trains and is usually considered negligible.

The maximum tractive force which may be developed by an electric or a diesel–electric motive power unit is determined by the weight on driving wheels and the coefficient of adhesion between the wheels and the rails. Tractive force equivalent to about 25% of the weight on drivers is about the maximum that can be utilized in starting a train on wet sanded rail. Adhesion may vary widely and depends upon the condition of the rails. It has been found by tests to vary inversely as the speed. Adhesion factors on wet rail, sanded, according to A. H. Candee, indicate that at 11 miles per hour (mph) the expected adhesion is about 18%; at 30 mph, 14%.[2] Tractive force in excess of the maximum that the adhesion will sustain will cause the drivers to slip.

The calculations of acceleration are based on Newton's Second Law of Motion. If the net tractive force is in pounds, the weight W in tons and the corresponding acceleration a is in mph per second,

$$a = \text{Net Tractive Force}/91.1\ W \qquad (2)$$

However, this does not allow for the force required to accelerate the rotating parts. Making an allowance for this, the equation in common use is

$$a = \text{Net Tractive Force}/100\ W \qquad (3)$$

As the net tractive force, the force available to produce acceleration, is the force in excess of all the resistance forces that must be overcome, the equation may be written for acceleration on level tangent track as follows:

$$a = \frac{\text{TF} - (R_L + R_C + R_A)}{100\ W} \qquad (4)$$

where

a = Acceleration on level tangent track in miles per hour per second (negative for retardation)
TF = Total tractive force, pounds
R_L = Resistance of locomotive, pounds
R_C = Resistance of cars, pounds
R_A = Resistance caused by axle-driven generators for lighting and air conditioning, pounds
W = Total weight of train, tons

For convenience, we have abbreviated maximum acceleration on level tangent track to "MALT."

Fig. 1 shows, for level tangent track, curves of total tractive force of a 4,000-hp diesel-electric locomotive, total train resistance of the locomotive and 14 passenger train cars, the resistance caused by 12 of the 14 cars having axle-driven generators supplying power for the lighting and air conditioning load, and the resulting MALT for the train.

As the effect of a grade is to exert a force of 20 pounds per ton of train weight for each per cent of grade, the actual acceleration of a train operating with full throttle is

$$a = \text{MALT} - 20\ G/100 \qquad (5)$$

where

G = Grade, in per cent (positive if ascending, negative if descending)

Knowing the acceleration of the train, we can compute changes in velocity, time, and distance by the usual equations of kinetics. However, with each change in speed, there is corresponding change in the force producing that change. Therefore, to obtain accurate results, small increments of either velocity, distance, or time must be used and the results calculated step by step. This is a tedious and time-consuming process if done with slide rule and graphs. Each step in the process involves checking for every change in track data such as grades, curves, speed restrictions, etc.

CALCULATIONS BY DIGITAL COMPUTER

The Pennsylvania Railroad has recently applied a digital computer, the International Business Machines Corporation (IBM) model *650* data-processing machine, to the calculation of train performance, fuel, or electrical energy consumption in moving a train, and locomotive tonnage ratings.

The basic "programs" or lists of instructions for the application of the digital computer to these calculations were developed by Dr. E. R. Mullins, Jr. (Swarthmore College and IBM) and Dr. D. L. Thomsen, Jr. (IBM).

CALCULATION OF TRAIN PERFORMANCE

For train performance calculations, three sets of punched input cards are used: (1) the program (about 400 instructions); (2) the train MALT data, calculated beforehand for the train to be run (five cards); and (3) the track data (average about one card per mile of track).

The program of instructions and the train MALT data are loaded on the *650* memory storage drum; the track data cards are read consecutively and automatically by the machine as the calculations proceed.

Fig. 2 shows the information conveyed by 18 typical track data cards. One punched card is used for every point of change in track data and supplies the data ahead of it to the point represented by the next card.

Most of the track data can be obtained readily from the track charts used by railroads to provide, in convenient form, information such as this. However, some additional information is needed in connection with braking. The rate of braking deceleration must be specified. It is dependent upon such things as grade, weight on axles, wheel diameter, brake shoe contact pressure, area of contact, etc. Fairly accurate values have been determined for passenger trains, varying from about 1 mph per second for most locomotive hauled trains to about 2 mph per second for electric multiple-unit trains. Braking deceleration for freight trains varies widely, but a conservative value in general use is ¼ mph per second.

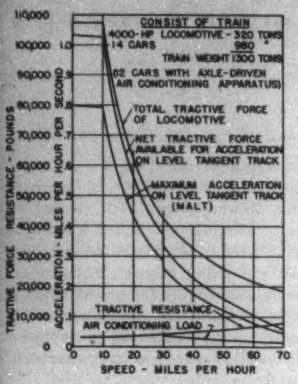
CONSIST OF TRAIN
4000-HP LOCOMOTIVE - 320 TONS
14 CARS 980 "
TRAIN WEIGHT 1300 TONS
(2 CARS WITH AXLE-DRIVEN AIR CONDITIONING APPARATUS)
TOTAL TRACTIVE FORCE OF LOCOMOTIVE
NET TRACTIVE FORCE AVAILABLE FOR ACCELERATION ON LEVEL TANGENT TRACK
MAXIMUM ACCELERATION ON LEVEL TANGENT TRACK (MALT)
TRACTIVE RESISTANCE
AIR CONDITIONING LOAD
TRACTIVE FORCE - RESISTANCE - POUNDS
ACCELERATION - MILES PER HOUR PER SECOND
SPEED - MILES PER HOUR

Fig. 1. Typical passenger train data.

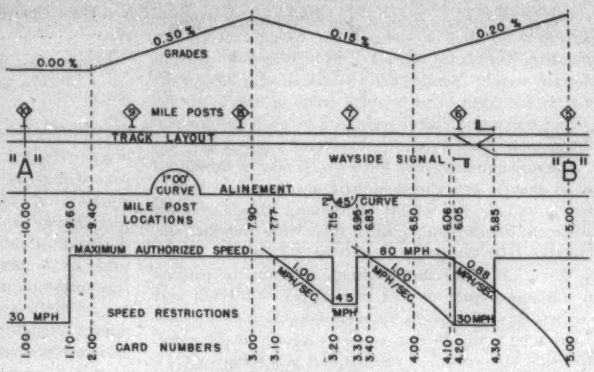

Fig. 2. Essentials of track data.

The beginning of the braking zone must also be specified by a track card. Braking from 80 to 45 mph at 1 mph per second will require 62/100 mile. So, in order to be down to 45 miles per hour at mile post location 7.15, the engineman should apply the brakes as the locomotive passes mile post location 7.77, if traveling at 80 mph at that point. Therefore, a punched card is inserted in the deck of track data to indicate the beginning of each braking zone and the rate of braking deceleration. However, braking action will not start until the train reaches the braking line. By braking line is meant the locus of points at which the braking action as specified will cause the train to decelerate in order to be precisely at the desired speed at the desired location.

Acceleration calculations take the following form: The MALT for the speed is obtained from the stored table by a linear interpolation, obtaining at the same time the slope m of the linear approximation of the MALT curve, which indicates the change in rate of acceleration for that speed. ΔV, the change in speed for the time interval Δt is calculated from the following:

$$\Delta V = a(1 + m\Delta t/2)\,\Delta t \qquad (6)$$

where

ΔV = Change in speed, mph
a = Acceleration, mph per second
m = Slope of linear approximation of MALT curve
Δt = The time increment, seconds

The calculations on the digital computer are carried out by first using a primary value for Δt. At the completion of each calculation of ΔV and Δx, the totals $V + \Delta V$ and $x + \Delta x$ are checked against the track data to ascertain whether the values thus obtained would result in a speed greater than authorized or a distance greater than that of the next change in track data. If neither of these limits will have been exceeded, the totals are recorded and the computation cycle is continued. If either of these limits has been reached, the last calculation is not totaled and a second cycle of computations is begun using a secondary value for Δt considerably less than the primary value. However, when the limit is reached, using the secondary value for Δt, the cycle is terminated.

If the limiting speed has been attained, time is calculated using that speed and using the distance to the next change in track data. If the limiting distance has been reached, data from the next card are read automatically into the machine and the calculations are resumed using the primary value for Δt.

Whenever the train enters a braking zone, the calculations take a different form. Tests are made to ascertain the time, place, and speed at which the train arrives at the braking line with the smaller secondary value of Δt. Braking action is then started, deceleration taking place at the rate b specified.

Even after the train enters the braking zone, operation will continue at full throttle until reaching the braking line. An exception to this occurs if the speed is below that of the speed restriction approached. In this case, the speed of the train in the braking zone will not exceed the speed restriction ahead.

CALCULATION OF CONSUMPTION OF FUEL OR ELECTRICAL ENERGY

If desired, the energy consumed in moving the train is computed as the train performance calculations progress. To accomplish this, the total weight of the train, a table of total tractive force vs speed, and a table of total train resistance vs speed are added to the train data.

Energy calculations are based on the equation

$$E = 0.002\ (\mathrm{TF})\ \Delta x \qquad (7)$$

where

E = Total energy delivered to the rims of the drivers, kw-hr
TF = Total tractive force, pounds
Δx = Distance traversed, miles

Table I. Output Data from Train Performance Calculation

Train	*132*		Locomotive	*GG-1*		
From	*Washington*		to	*New York*		
Tonnage	*1,200*	Cars	*18*	Air-Conditioned	*16*	Rails	*Dry*
Remarks	*Present Speed Restrictions*			Date	*8-26-57*	

1 Station	2 Mile Post	3 Distance	4 Speed	5 Minutes	6 Kw-Hr
Washington	135.85	0.00	0.0	0.0	0
N.Y. Ave.	134.95	0.90	17.1	4.1	65
Landover	128.70	7.15	80.0	10.4	466
Bowie	120.70	15.15	79.9	16.5	820
Odenton	113.50	22.28	80.0	21.9	1,146
Fulton	97.50	38.15	30.0	34.8	1,529
Baltimore	95.60	40.05	0.0	39.6	1,529

In the case of full-throttle operation, the tractive force is obtained from a table of maximum tractive force vs speed. For partial throttle at constant speed, the total resistance is used to indicate the tractive force. During drifting or braking, no propelling power is supplied.

The energy thus calculated is the energy delivered at the rims of the driving wheels. By the use of the proper efficiency or conversion factor, the energy input at the pantograph or amount of fuel consumed can be derived.

Fig. 3 shows the flow chart for the calculation of train performance and energy consumption. The program may be entered at several different locations on the memory storage drum, as follows:

ALLPT (punch all points). This will cause an output card to be punched at every location designated by a track card. It is used principally in providing a comparison with results calculated by other methods. By its use, a rough graph can be plotted of speed vs time or distance.

STAPP (punch stops and passing points). This is self-explanatory. It is the method most frequently used.

ENERGY (compute energy). This is used when energy calculations are desired.

NO-EN is used to reset the program to normal, that is, without calculating energy.

Typical tabulated output data are illustrated in Table I.

CALCULATION OF LOCOMOTIVE TONNAGE RATINGS

THE CALCULATIONS of maximum permissible tonnage ratings for locomotives are handled in a somewhat different manner. In these problems, we are not concerned with train operating time. We want to know the maximum tonnage a locomotive can haul from "A" to "B" regardless of the time required to make the run.

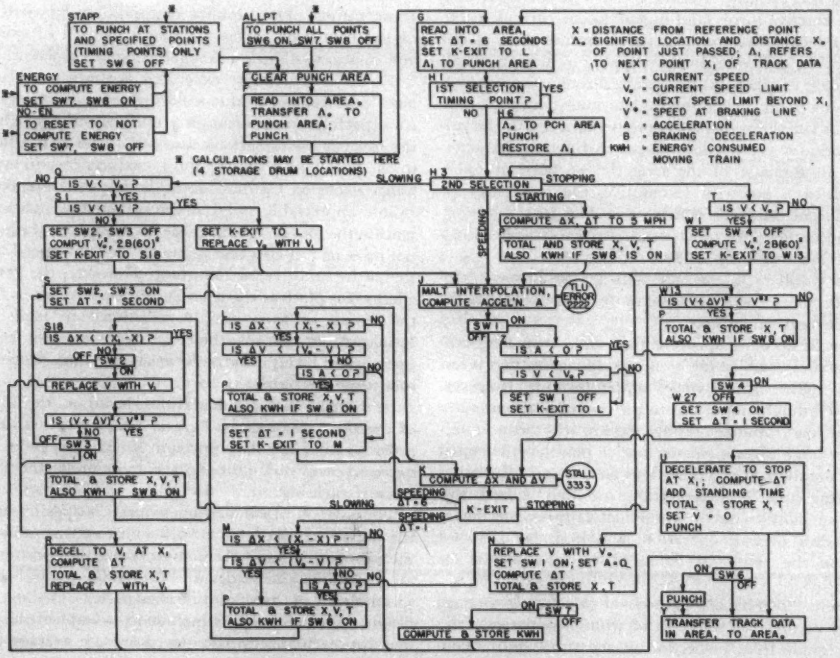
STAPP
TO PUNCH AT STATIONS AND SPECIFIED POINTS (TIMING POINTS) ONLY
SET SW 6 OFF
ALLPT
TO PUNCH ALL POINTS
SW6 ON, SW7, SW8 OFF
ENERGY
TO COMPUTE ENERGY
SET SW7, SW8 ON
NO-EN
TO RESET TO NOT COMPUTE ENERGY
SET SW7, SW8 OFF
CLEAR PUNCH AREA
READ INTO AREA, TRANSFER A0 TO PUNCH AREA; PUNCH
CALCULATIONS MAY BE STARTED HERE (4 STORAGE DRUM LOCATIONS)
READ INTO AREA, SET ΔT = 6 SECONDS SET K-EXIT TO L, A1 TO PUNCH AREA
1ST SELECTION TIMING POINT ?
A0 TO PCH AREA PUNCH RESTORE A1
X = DISTANCE FROM REFERENCE POINT
A0 SIGNIFIES LOCATION AND DISTANCE X0 OF POINT JUST PASSED; A1 REFERS TO NEXT POINT X1 OF TRACK DATA
V = CURRENT SPEED
V0 = CURRENT SPEED LIMIT
V1 = NEXT SPEED LIMIT BEYOND X1
V' = SPEED AT BRAKING LINE
A = ACCELERATION
B = BRAKING DECELERATION
KWH = ENERGY CONSUMED MOVING TRAIN
IS V < V0 ?
IS V < V1 ?
SET SW2, SW3 OFF COMPUT V'2, 2B(60)2 SET K-EXIT TO S18
SET K-EXIT TO L REPLACE V0 WITH V1
SLOWING
2ND SELECTION
STOPPING
STARTING
SPEEDING
COMPUTE ΔX, ΔT TO 5 MPH
TOTAL AND STORE X, V, T ALSO KWH IF SW8 IS ON
IS V < V0 ?
SET SW 4 OFF COMPUTE V'0, 2B(60)2 SET K-EXIT TO W13
SET SW8, SW3 ON SET ΔT = 1 SECOND
MALT INTERPOLATION, COMPUTE ACCEL'N A
TLU ERROR 2222
IS (V+ΔV)2 < V'2 ?
IS ΔX < (X1 - X) ?
IS ΔV < (V1 - V) ?
IS A < 0 ?
IS V < V0 ?
SET SW I OFF SET K-EXIT TO L
TOTAL & STORE X, V, T ALSO KWH IF SW 8 ON
SET ΔT = 1 SECOND SET K- EXIT TO M
REPLACE V WITH V1
IS (V+ΔV)2 < V'2 ?
TOTAL & STORE X, V, T ALSO KWH IF SW8 ON
SW 4 ON
W 27 OFF
SET SW 4 ON SET ΔT = 1 SECOND
COMPUTE ΔX AND ΔV
STALL 3333
SLOWING ΔT = 6
SPEEDING ΔT = 1
K-EXIT
STOPPING
DECELERATE TO STOP AT X1; COMPUTE ΔT ADD STANDING TIME TOTAL & STORE X, T SET V = 0 PUNCH
DECEL. TO V1 AT X1 COMPUTE ΔT TOTAL & STORE X, T REPLACE V WITH V1
IS ΔX < (X1 - X) ?
IS ΔV < (V1 - V) ?
IS A < 0 ?
TOTAL & STORE X, V, T ALSO KWH IF SW 8 ON
REPLACE V WITH V0 SET SW I ON; SET A=Q COMPUTE ΔT TOTAL & STORE X, T
SW 6
PUNCH
TRANSFER TRACK DATA IN AREA, TO AREA0
SW 7
COMPUTE & STORE KWH

Fig. 3. Flow chart for train performance calculations program.

In general, the maximum permissible tonnage rating for a given route is limited by what the locomotive can haul up the ruling grade. By ruling grade is meant the most difficult grade the train will encounter on that route. That sounds like a rather simple definition. However, with the exception of a long uniform grade, it is not always easy to identify the ruling grade and to ascertain its average steepness or its length, particularly in what may be called rolling terrain.

The ruling grade is not always the steepest grade. The steepest grade may be only a few hundred feet long. Generally speaking, the answer to the question, "What is a ruling grade?" depends on steepness, length, and conditions of grade and of train speed approaching the foot of the grade in question.

This introduces the subject of "momentum operation." Obviously, the faster a train is moving as it reaches the foot of a steep grade, the greater is the kinetic energy stored in the train to assist it in surmounting that grade. To be "ruling," a grade must be long enough and steep enough to reduce the speed of the train to what we may call the locomotive "rating speed." If the lowest speed on the grade is greater than the rating speed, the full tonnage rating of the locomotive is not being utilized.

The rating speed may be determined by one of several limitations, but it is usually the lowest speed at which the locomotive can be operated for an unlimited time at full throttle. A lower speed with corresponding higher tractive force (and higher motor current in the case of locomotives with electric transmissions) is not practicable, as it would cause slipping of driving wheels or damage to electrical insulation through overheating.

At this point, it may be well to note that the grade which is ruling for one locomotive might not be the ruling grade for another locomotive of different characteristics. In the case of the long freight train of today hauled by a powerful locomotive, the train may be longer than the grade which was ruling for a less powerful locomotive. In other words, on a rolling profile, a train may "overhang" one or more grades.

As a corollary to this, the tonnage rating for a two-unit locomotive will often be more than twice that for a single unit, and so on.

Thus, it becomes apparent that, except for long uniform grades, establishing accurate tonnage ratings is not an easy matter of applying a simple formula. However, it is exceedingly important to the economical operation of a railroad. Tonnage ratings too low will mean unnecessarily large investments in motive power with related larger maintenance facilities and greater crew and other operating costs. Tonnage ratings too high, if used, will result in more frequent equipment failures and detentions, slow over-all operation, and high maintenance costs as the result of damaged traction motors or generators.

Present "long-hand" methods of calculating tonnage ratings involve the selection of what is apparently the ruling grade from inspection of the track chart. Tonnage rating is then calculated by the equation

$$T = \frac{P - 20\,Gw}{r + 20\,G} \tag{8}$$

where

T = Tonnage, trailing tons gross weight
P = Drawbar pull, pounds
G = Grade, per cent
w = Weight of locomotive, tons
r = Tractive resistance of cars, pounds per ton

Studies made of a variety of typical conditions involving momentum operation over a rolling profile demonstrated that, with rated tonnage, an averaged grade having a length *approximately* twice that of the train would, in general, result in a reduction in speed to about the minimum rating speed. That is to say, with momentum operation, to be ruling, such grade should be at least twice the length of the train. However, this rule is not exact and tonnage ratings thus obtained should be checked by other means.

Obviously, to be ruling, without momentum operation, the averaged grade must be at least as long as the train.

Checking tonnages thus calculated can hardly be accomplished manually by the step-by-step process because of the tremendous number of computations involved. It can be done with the Pennsylvania Railroad Train Performance Calculator[8]; but even with this analog computer, the process requires too much time to check many ratings. The rapidity of computations with the digital computer makes possible a method of quickly and easily calculating tonnage ratings accurately.

There is one major difference between calculating train performance and calculating tonnage ratings. In train performance, to simplify the work, the weight of the train is almost always assumed to be concentrated in one point. This assumption introduces certain errors. Calculations on this basis indicate that the train begins to lose appreciable speed at the instant the locomotive reaches the foot of a steep grade. Actually, the grade will not have its full effect on reducing the train speed until the entire train is on the grade. However, the reverse effect takes place as the train passes over a summit. Over the length of runs usually considered in train performance calculations, these two types of error cancel each other nicely, and sufficiently accurate values of total time are obtained.

In tonnage rating calculations, however, the length of the train becomes an item of prime importance. In order to calculate the minimum speed accurately, it is necessary to evaluate the average grade under the whole train at each instant.

The method of calculating tonnage ratings by use of the digital computer is as follows: Stored in tables on the memory drum of the computer are the locations of all grade lines, the grades, and the maximum authorized speed ahead of each point of change in track data. Sufficient approach track is included to establish the normal approach speed. Also stored are the average gross weight per car and a table of tractive resistance vs speed.

Weight and drawbar pull data for each locomotive or group of locomotives are contained in a set of three cards to be read as each group is rated in turn. To start, an estimated tonnage is assigned to the first locomotive. The computer, with this tonnage, calculates a run over the prescribed distance, noting the minimum speed of the train. If the minimum speed noted is too low, indicating trial tonnage too great, another run is made automatically with 200 tons less. If the minimum speed noted is not low enough, another run is made automatically with tonnage increased 3%, but not less than 25 tons. These calculations are repeated automatically until the minimum speed is sufficiently close to that desired, or the maximum permissible length of train has been exceeded.

Having calculated the tonnage rating for one group of locomotives, the data for the next group are read from the next three cards. As a trial tonnage for the second group, the computer will start with a tonnage proportioned to the rated tonnage of the preceding group in the ratio of the rated pulling powers of the two groups.

A portion of the tabulated output data from a tonnage rating calculation is shown in Table II. Items are as follows:

Column 1. By group is meant one or more classes of locomotive having sufficiently similar operating characteristics to be rated alike.

Columns 2 and 3. Gross weight (tonnage) and number of cars.

Columns 4, 5, and 6. Distance, speed, and time at the point of data punch out. These items, when obtained at periodic short intervals of time by using the "time punch" routine, provide means of drawing a curve of the variables or of otherwise analyzing the train movement.

Columns 7 and 8. The minimum speed and the location at which it occurred.

Column 9. Punch identification, coded as follows: 0 – Tonnage high; 2 – Tonnage low; 5 – Tonnage rating.

Table II. Output Data from Locomotive Tonnage Rating Calculation

Route *Akron* to *Hudson*
Section *Entire Distance, Mile Post 15 to Mile Post 0*
Locomotive Groups *206-211* Tons per car *40*
Initial Speed *35* mph at *Mile Post Location 14.85* Rails *Wet*

1 Group	2 Tons	3 Cars	4 Dist.	5 Mph	6 Time	7 Min. Speed	8 At Dist.	9 Ident.
206	3,910	98	16.81	15.24	30.6	14.72	16.66	5
207	5,070	127	16.80	15.12	31.2	15.11	16.75	5
208	4,680	117	16.83	11.96	35.0	10.95	16.65	5
209	4,880	122	16.83	12.16	35.6	11.17	16.63	5
210	5,065	127	16.81	11.73	35.6	11.06	16.66	5
211	6,410	160	16.82	14.99	32.2	14.99	16.82	5

CONCLUSIONS

The Pennsylvania Railroad Train Performance Calculator has proved to be a profitable investment. Because of the reduction in calculating time, many investigations and studies of ways of improving the train service, of improving the efficiency and economy of operation, and some of the investigational work preparatory to the purchase of new locomotives have been accomplished which might not have been attempted without the calculator, because of the number of man-hours required to make these calculations by hand.

It now appears that the use of the digital computer for this work makes possible a further, and very much greater, reduction in calculating time. Train performance is calculated at rates varying between 700 and 2,000 miles of track per hour depending on the number of station stops, speed restrictions, and grades. Tonnage rating calculations on the digital computer require from 1 to 5 minutes per locomotive group depending on the length of track involved.

Because of the great reduction in time, the use of the digital computer has been found advantageous in calculating train performance and locomotive tonnage ratings. Being a general-purpose machine, it can be used also for a great variety of other data-processing work.

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3. A New Train Performance Calculator, S. V. Smith. AIEE *Transactions*, vol. 70, pt. I, 1951, pp. 657-61.

Cockpit Television Set

An airborne closed-circuit television device that pictures constantly for the pilot the exact location of his plane in relation to the ground has been announced. The device, called the "Horizontal Situation Display," automatically correlates information fed into it by navigational computers and instruments and presents a television picture in the form of a map of the terrain below the plane. A plane image, projected over the map, always corresponds to the pilot's exact position over the terrain.

The electronic system was developed by Avion Division of ACF Industries, Inc., under contracts awarded by the Weapons Guidance Laboratory at Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. It has been described as one of the most significant advances since the airborne computer in simplifying navigational problems for jet pilots.

The display permits the pilot to have before him a continuous and automatic pictorial presentation of the aircraft's geographical position and flight track, thus eliminating the necessity for bulky charts and hand computers.

Pictorial Review

Missiles Manufactured by Automated Machine Tool Line

ELECTRONIC CONTROLS run by Digitape, expected to play an important part in "crash" development programs such as that in guided missiles, is explained by R. M. Russell *(top left)*, Hughes Aircraft Company vice-president and products group chief executive. He holds machined part used in armament control apparatus for U. S. Air Force all-weather interceptor, and points to standard blueprint from which tapes (unrolled on table) are punched.

One of the nation's first all-electronically controlled machine tool lines *(center left)* embodies new technological progress in factory automation. Engineer Wesley Niemond is shown checking line of machine tools developed in cooperation with Kearney and Trecker Corporation, Milwaukee, Wis. Working as a team, milling, drilling, and boring machines (left to right) pass parts along automatically after each operation has been completed. This enables Hughes to run "Detroit" type production techniques for small job lots which constitute most industry machining.

Lights flash "thoughts" guiding automatic factory as engineer Ben Suleski *(bottom left)* monitors computer circuitry of Hughes Aircraft plant in Los Angeles, Calif. All information sent to machines by new Digitape controls flows through this bank of contact relays and blinker lights, sharply reducing time from blueprints to finished parts, thus speeding up defense program.

Control cabinets for Digitape automated machine tool line *(bottom center)* shows at extreme right the master control panel which can start and stop tape readers, machines, and transfer line. Next toward the left are four tape readers that feed tape through sensitive metal fingers that "feel" the punched information. Further to the left are controls for boring machine where information from the tape readers is converted into instructions for machine movement and operation. Research assistant is shown making routine drilling machine check. At extreme right is milling machine control cabinet.

Technician *(bottom right)* removes armament control system part for interceptor planes. The advantages of simultaneous manufacture are: precision is built into line, typist-punched tapes and one operator, set-up operation virtually eliminated, tooling is approximately 50% less, changes in product even during production run (by splicing tape), spare parts and reorders quickly and economically made, and simple dial adjustments to correct variations in cutting edge dimensions. Howard Hughes, company president, and a team of company scientists were the only ones who knew of the operation until the success of the manufactured parts had been proved.

ELECTRICAL ENGINEERING EDUCATION

AIEE in Lamar State College of Technology

ON APRIL 14, 1955, the Board of Directors authorized the establishment of the first Student Affiliate Branch of the AIEE at Lamar State College of Technology in Beaumont, Texas. At that time, the department numbered 133 students with 9 seniors and 3 staff members. Of this number, 46 held student memberships in AIEE. Prof. L. B. Cherry, head of the electrical engineering department, was named counselor. Today, the department numbers 272 students with 39 seniors and 6 staff members. Of this number, 52 are student members of AIEE. The present counselor is Asst. Prof. J. L. Cooke. The activity of the Branch is indicated by the fact that for the past two successive years they have won the plaque awarded by the local branch of the Texas Society of Professional Engineers to the department having the best Engineers' Day exhibit.

ASEE Reports on Research in Engineering Colleges

AMERICAN engineering colleges—already carrying on nearly half of the government-sponsored basic research in engineering now under way in the United States—called recently for expanded national support for fundamental research and promised to assume even greater responsibilities for its success.

In a comprehensive summary of the status and needs of research in engineering colleges, The American Society for Engineering Education (ASEE) said:

1. Engineering research valued at $100 million a year is now in progress on college campuses.

2. Another $10 million could be accommodated immediately with present staff.

3. The progress of engineering in future years in the United States requires a greatly expanded program of basic research today in all technical fields.

4. Increased support of research in educational institutions is vital for the professional development of the faculties, for new knowledge which will result, and for the qualified students it will help train.

5. Budget uncertainties of late 1957 damaged the "good relationships and the spirit of mutual confidence" which had been built up between the Defense Department and educational institutions. Many cuts remain unrestored, and some new programs are still uncertain.

Highlighting the report, Dr. F. C. Lindvall, president of ASEE and chairman of the Division of Engineering at the California Institute of Technology, declared, "Research is an integral part of modern engineering education as well as the foundation upon which new technology is built." In a letter to Dr. J. R. Killian, Jr., the President's adviser on science and technology, Dr. Lindvall further stated, "It is clear that many of our present difficulties in research, development, and practical utilization of new ideas are due to the fact that we need more engineers of high quality. This engineering deficiency must be kept in sharp focus by specific identification in all measures, legislative and otherwise, directed toward strengthening Science and Engineering." Through continuing and expanded college research support, the United States can today achieve two vital purposes:

"We can," he continued, "increase our basic knowledge in engineering and the engineering sciences. And we can strengthen engineering education to meet growing demands, assuring the nation of more well-qualified graduates to enter research laboratories and teaching careers."

Of the $100 million in engineering research now under way in colleges and universities, at least $65 million is financed by contracts and subcontracts with military agencies, according to figures compiled by Renato Contini of New York University for publication in the ASEE 1957 Review of College Research. Industrial and foundation-supported projects total $21 million.

At least 7,000 individual research projects are listed in the "1957 Research Review," published by the ASEE's Engineering College Research Council (ECRC), of which Mr. Contini is secretary. The reports come from 110 colleges and universities holding ECRC membership, the leading campus research centers in the nation.

Another ECRC survey, covering 108 institutions, shows 6,429 engineering faculty members whose research activities represent the equivalent of 1,668 man-years. But, according to Prof. R. H. Ramsey of the college of engineering at Pennsylvania State University, who is director of a major study of engineering college research potential under way for the National Science Foundation by ECRC, 549 additional equivalent man-years remain available immediately for research.

"Using $18,000 per year as the sum required to finance one full-time research worker, the 549 equivalent man-years available means that $10 million more could be spent before our leading colleges reach their full engineering research potential," Prof. Ramsey points out in a project progress report.

To realize this potential is only a small part of the task ahead, however, according to the ASEE's Committee on the Development of Engineering Faculties.

In recommendations to Dr. Killian

Electrical Engineering Education

(*Electrical Engineering*, April 1958 p. 333), prepared by Dr. W. L. Everitt, dean of the college of engineering at the University of Illinois, the Committee says that "the support of basic research in engineering and the form in which it is offered are of the utmost importance to the nation."

Because research is the "most essential and costly component of advanced education," the Committee report to Dr. Killian declared, "research support determines not only the amount of research accomplished but also the supply of individuals with the background necessary to teach engineering in an age when basic understanding of scientific principles must replace dependence on intuition and experience."

To strengthen engineering college research, the Committee (of which Dean H. L. Hazen of the Massachusetts Institute of Technology is chairman) recommended a five-point program to Dr. Killian.

1. Increase the number and amount of basic research contracts with universities.
2. Encourage the participation of graduate students in basic research projects.
3. Make sure that universities are fully compensated for indirect as well as direct costs of research—including the salaries of those faculty members directing projects.
4. Provide Federal funds for building or enlarging universities' facilities for fundamental engineering research.
5. Provide long-term basic research contracts with universities, "so that areas of competence may be developed and supported without straining educational resources through contract instability."

Dr. R. J. Woodrow of Princeton University who is vice-presiden: of the ASEE and chairman of its ECRC, called for firm assurances from Federal agencies and from Congress for the future support of engineering colleges' research, so that colleges may make adequate preparations for continuing and expanding these activities.

Dr. Woodrow believes that sudden reductions of Defense Department research expenditures and appropriations late in 1957 "should rightfully be called disaster." He cited among effects on university research the breakup of research teams and "damage to mutual confidence.."

"Every project," he declared, "no matter what its status, suffered the harassment of curtailments, expenditure limitations, and delays in the execution of extensions.

"This time, of all times, with Russia making giant strides in science and engineering, demands the very best in co-operation and mutual confidence between the Government and our educational institutions," Dr. Woodrow declared.

Wear Your ✦ AIEE Badge

Three Southern States Sponsor "Traveling Teachers"

Three southern states—Georgia, South Carolina, and Tennessee—are spearheading a plan to stimulate science teaching in their schools by sending specially trained "traveling teachers" on lecture-demonstration tours.

The Oak Ridge Institute of Nuclear Studies (ORINS), Oak Ridge, Tenn., has announced that the departments of education in the three states will sponsor a total of 13 high school science teachers to spend the 1958-59 academic year traveling within their respective borders. The teachers will spend a three-month preliminary training period at ORINS.

Georgia will sponsor 10 of the teachers; South Carolina, two; and Tennessee, one.

The states are undertaking this activity through the Oak Ridge Traveling Science Demonstration Lecture Program, jointly sponsored by the National Science Foundation (NSF) and the U.S. Atomic Energy Commission (AEC), and administered by ORINS. The latter is a nonprofit educational corporation of 36 southern universities and colleges. The ORINS University Relations Division, which handles the program's administration, is headed by W. W. Grigorieff; J. E. Bowles is coordinator of the program.

Aim of the program is the stimulation of interest on the part of high school students in science and science careers. In the first two years of the program, the "traveling teachers" were supported by the NSF and the AEC; 7 teachers were selected for the 1956-57 school year and 10 for the present 1957-58 year. It is ORINS' plan to increase the number to 22 for the 1958-59 school year, with 7 teachers to be supported by the NSF and 15 to be supported by individual states, with NSF and AEC assistance. The NSF-sponsored teachers will visit schools in several states; the state-sponsored teachers will confine their visits to schools within their respective state boundaries. The 10 Georgia teachers, for example, will visit all 360 high schools in that State during the coming year.

Several other states have expressed strong interest in sponsoring one or more teachers for the coming year, and are now attempting to work out arrangements to permit such sponsorship. The list includes Oklahoma, Iowa, Vermont, Illinois, Florida, and Massachusetts. Each of the states involved will make the selection of its own teachers; the seven "teachers-at-large" will, as in the past, be selected by a special committee composed of staff members of ORINS and the Oak Ridge School system.

The chosen teachers will participate in a three-month training program at Oak Ridge that will include attending a one-month summer institute for secondary school science teachers. The training program is specially designed to upgrade the traveling teacher's subject-matter background, acquaint them with latest laboratory practices, and provide them with lecture-demonstrations that will enhance the science programs of schools visited. An interesting feature of the program is the use of homemade apparatus, designed and constructed by the traveling teachers, which can be easily and inexpensively reproduced by students and teachers in the schools visited.

After this intensive training course, the teachers, at the beginning of the 1958-59 school year, will begin visiting schools in their assigned territories. Assignments of the state-supported teachers will be made by their respective state departments of education; the seven teachers-at-large will follow itineraries prepared by ORINS, with each teacher using his home city as a base, to permit his spending week ends and holidays with his family.

The 1957-58 program was also assisted by the Ford Motor Company, which furnished vehicles, the Gulf Oil Corporation, which furnished fuel, and the Bell Telephone System, which provided solar batteries for demonstrations.

Engineering Institutes at The University of Wisconsin

The following Engineering Institutes are being sponsored during May and June by the University of Wisconsin Extension Division in co-operation with the College of Engineering and professional engineering societies: Industrial Control Applications, May 1-2; Engineering Refresher (Mechanical Engineering), May 5-6; Industrial Product Design, May 8-9; Seminar for Chief Industrial Engineers, May 13-14; Power Plant Practice, May 20-23; Engineering Organization, May 22-23; Engineering Refresher (Electrical Engineering), May 26-27; Industrial Packaging, May 27-28; Consulting Engineers—Professional and Management Problems, June 5-6.

Engineering Institutes are meetings of two to five days duration which present current information to technical personnel from industry. To keep abreast of rapidly changing technology most companies find this continual up-dating of their personnel a necessity. Inasmuch as most of the programs deal with industrial operations, speakers who are recognized authorities in their fields are obtained from manufacturing concerns. Specialists from research laboratories, consulting firms, and the faculty of the University of Wisconsin and other educational institutions are selected when the subject matter is appropriate. Material is presented in informal talks, panel discussions, films, slides, and demonstrations.

For more information, write: Engineering Institutes, University Extension Division, The University of Wisconsin, Madison 6, Wis.

IIT Receives Grant for Faculty Development

A $1,500 grant to promote development of the faculty in professional areas has been awarded to Illinois Institute of Technology (IIT), Chicago, Ill.

The grant is part of the "Shell Assists" program sponsored by Shell Companies Foundation, Inc., New York, N.Y.

Under the new program, IIT and 49 other privately supported institutions have received grants from Shell, according

to J. C. Boyce, vice-president of academic affairs at IIT.

"Shell Assists" are aimed to enable increased faculty participation in professional society meetings, personal research and research publication, and scholastic travel, as well as to initiate participation in new scholastic professional activities.

The donations are three-phase—$500 for the professional development of a specific faculty in an engineering, mathematics, or physical science department; $500 for the professional development of the institution's academic faculty as a whole, and $500 to use as the institution sees fit to increase the general support of higher education.

Philip Sporn Fellowship Available

The Catherwood Foundation has announced that the Philip Sporn Fellowship of $2,500 per annum for graduate work at The Ohio State University in the field of electric generation and distribution will be available again this coming year, 1958-59. The payments are applied first to tuition expense, and the remainder is paid directly to the recipient of the fellowship. Tuition is $75 per quarter and out-of-state fees for nonresidents of Ohio are waived. The only requirement necessary to qualify for this fellowship is that the applicant must be a citizen of the United States.

Requests for applications and further information should be addressed to: E. E. Dreese, Chairman, Electrical Engineering Department, The Ohio State University, Columbus 10, Ohio.

Prof. Pumphrey Named Dean of Engineering at API

F. H. Pumphrey (F '48), formerly professor of electrical engineering at the University of Florida, Gainesville, Fla., has been appointed dean of engineering at Alabama Polytechnic Institute (API), Auburn, Ala.

Prof. Pumphrey received his bachelors degree in electrical engineering in 1921 and the professional E.E. degree in 1927 from Ohio State University. He had been a faculty member at the University of Florida since 1946. The new dean is a member of Phi Beta Kappa, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

Western Technical Writing Institute, San Marino

Western Technical Writing Institute (WTWI) was founded in 1955 in Pasadena, Calif., and moved to San Marino, Calif., in 1957. Judged against colleges and universities, the WTWI's physical assets are infinitesimal. Its nation-wide reputation has come from the quality of instruction. Because instruction is intended for engineers, other professionals, and industrial executives, only night classes are held. All courses have been planned by J. L. Kent, well-known writer, editor, and teacher in industrial communications. The courses include:

Technical Writing Techniques. A basic improvement course for engineers and industrial executives. Course covers both lectures and practice in the major forms of industrial writing—reports, technical articles, proposals, sales bulletins, manuals, and company periodicals. The 10-session course is given twice a year. Next one begins May 3. Fee is $70.

Engineering Article Writing. This is a course for engineers, running eight evenings. The object is to teach how to produce technical articles effectively and efficiently using methods of professional writers. Next course is scheduled for Fall 1958. The fee is usually $60.

Industrial Communications Improvement. This is a management course running six sessions. It covers advertising and sales literature, industrial advertising in trade journals, company publications, letters, proposals, annual reports, and other corporate communications. Both writing and format are discussed. The next course is scheduled for September 1958. Fee is $120.

In addition, the WTWI sponsors (in cooperation with local chapters of national engineering societies) the Southern California Industrial Writing Institute, an annual conference lasting three days.

The director is Henry Duval, 2427 Huntington Drive, San Marino, Calif. In keeping with its policy of doing everything to encourage engineers and industrial people to write, the WTWI does not have a phone.

Electrical Engineering Education

An Electrical Engineer in Education

Photo by Gus Robinson

W. J. MILLER (AM '19, F '43, Member for Life), professor and head of the electrical engineering department, University of Alabama.

"Engineering is by nature a teamwork profession. Each member of the profession needs association with other engineers for a successful career. The founding fathers in 1884 included in their rules for the AIEE the significant statement that its objectives would be achieved 'by means of meetings for social intercourse, the reading and discussions of professional papers, and their circulation, by means of publications among its members and associates, of the information thus obtained.' The wisdom of this recognition of the basic need for social intercourse among engineers to promote effectiveness of group activities has been shown by the successful record of the Institute.

"In addition to the activities associated with the development and dissemination of new knowledge in the field of electrical engineering, the Institute has become engaged in efforts to raise professional standards of the engineer. One of the most important of these is the Engineers' Council for Professional Development (ECPD) program of accreditation of engineering schools. This has been supported by the Institute as the representative of all electrical engineers. This activity has raised the standards of engineering education very significantly and increased the recognition of the profession very greatly during the past two decades.

"The Institute also represents all electrical engineers in Engineers Joint Council which has done important work in seeking to make the profession more useful to society and more effective in development of our national resources.

"The Engineering Societies Library, which is supported by the Institute and its members, is one of the largest in the world and plays a prominent part in the advancement and effectiveness of the engineering profession.

"The biennial Membership Directory of the Institute is essentially the 'Who's Who' of the electrical division of the engineering profession. To be included among this group of outstanding electrical engineers is a definite distinction. This listing gives the individual identity in his profession and furnishes information to his colleagues as to his location and connections. This is a valuable asset.

"From the foregoing it is seen that membership in the Institute enables the electrical engineer to (1) be identified as a professional man, (2) associate and become acquainted with the leading members of the profession in Section, District, and General Meetings, (3) participate in presentation and discussion of new developments in electrical theory and application, (4) share in the support of activities to raise the standards of engineering education, (5) assist in making the profession of more value to society, and (6) fulfill the 'second mile' of professional obligation.

"No electrical engineer can afford to

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miss the benefits, advantages, and the opportunity to enrich his professional life from contributions to the common good offered by Membership in the American Institute of Electrical Engineers."

Prof. Miller, who served as vice-president of the Institute for District No. 4 during 1955-57, received the bachelor's degree in electrical engineering from the University of Texas in 1915 and the degree of S.M. in E.E. from Massachusetts Institute of Technology (MIT) in 1922. He was associated with General Electric Company (GE) from 1915 to 1917 when he returned to the University of Texas as an instructor in electrical engineering and war training courses. In 1919, he was promoted to adjunct professor of electrical engineering. He served as part-time instructor of electrical engineering while pursuing graduate study at MIT in 1920-21. During 1921-23, he was head of the department of electrical engineering at Oklahoma A & M College. Then, in 1923, he became the first director of the new engineering experiment station at the University of Arkansas. In 1925, he accepted an appointment as dean of engineering to organize the school of engineering in the new Texas Technological College. Seven years later he resigned this position to become head of the department of electrical engineering at the University of North Carolina. While at this institution, he also served for two years as acting-dean of engineering. Since 1936, he has been professor and head of the department of electrical engineering at the University of Alabama. At various times during his career in education, he was employed by GE, Westinghouse Electric Corporation, Texas Power & Light Company, and other organizations to work on special problems. He is a member of several engineering and educational societies including the American Society for Engineering Education, Tau Beta Pi, Eta Kappa Nu, and Sigma Tau. In addition to membership on national committees, Prof. Miller has served the Institute as Student Branch Counselor in each of the colleges in which he has taught, as chairman of the Alabama Section, as chairman of District No. 4 Membership Committee, and as representative of the Institute for 15 years in the ECPD engineering curricula accrediting program.

Yale University Joins AURA, Inc.

Yale University has joined the Association of Universities for Research in Astronomy, Inc. (AURA), according to word received by A. T. Waterman, director of the National Science Foundation (NSF), from R. R. McMath, president of AURA, Inc. Inclusion of Yale University was acted upon favorably at a recent meeting of the Board of Trustees. Yale will be represented on the Board by Dr. Rupert Wildt, associate professor of astrophysics, and C. S. Gage, treasurer, Yale University.

AURA, Inc., is under contract to the NSF for the establishment and management of a new national astronomical observatory, to be located in Arizona on a site as yet undetermined. In addition to Yale, the group also includes: California, Chicago, Harvard, Indiana, Michigan, Ohio State, and Wisconsin. All member universities of the association have strong programs of research and graduate instruction in astronomy.

ECPD Survey of Engineering Enrollment

The principal findings are summarized of the 1957 annual survey of engineering enrollments and degrees in colleges which have one or more curricula accredited by the Engineers' Council for Professional Development (ECPD). The survey covers 152 such colleges in the United States and its possessions. The survey is made by the U. S. Office of Education in co-operation with The American Society for Engineering Education (ASEE).

The report by S. J. Armore, chief, statistical services section, research and statistical services branch, U. S. Office of Education, and Dr. H. H. Armsby, chief for engineering education, Division of Higher Education.

1. Total engineering enrollment in the United States and its outlying parts in institutions accredited by ECPD reached an all-time high of 257,777 students in the Fall of 1957. This represented a 5.5% rise over the previous peak of 244,390 students reported in 1947.

2. Engineering enrollment has shown year-to-year increases since 1951.

3. In the Fall of 1957, total male engineering students in ECPD accredited institutions made up 12.8% of total male degree-credit enrollment, compared with 12.5% a year earlier.

4. The enrollment of 67,071 freshmen in the Fall of 1957 was 1% higher than in 1956. All other classes of enrollment in ECPD accredited institutions, except sophomores, also showed increases.

5. Part-time and evening undergraduate engineering enrollment in the Fall of 1957, reported 30,458 students, was 17.1% above that of 1956.

6. Enrollment for the master's degree in the Fall of 1957 in ECPD accredited institutions increased 7.6% over 1956.

7. Enrollment for the doctor's degree in the Fall of 1957 in ECPD accredited institutions, 4,180 students, increased a substantial 22.9% from the 1956 registrations.

8. Evening student enrollment for the doctor's degree in ECPD accredited institutions in the Fall of 1957, 690 students, increased very substantially, 30.7% above 1956.

9. During the 1956-57 academic year, 27,748 first-level engineering degrees were awarded by ECPD accredited institutions —a noteworthy increase of 17.8% over the 1955-56 awards.

10. First-level degrees in engineering awarded during 1956-57 constituted 8% of the total first-level degrees (estimated), a higher percentage than the 7.6% observed for 1955-56.

11. A total of 5,203 master's degrees in engineering was granted by ECPD accredited institutions—an 11.2% increase over 1956.

12. ECPD accredited institutions granted a total of 596 doctor's degrees in engineering in 1956-57—2.3% fewer than in the 1955-56 academic year.

13. During the 1956-57 academit year, the highest percentage of engineering degrees awarded by ECPD accredited institutions for first-level, master's, and postgraduate predoctoral degrees was in the field of electrical engineering. For the doctor's, the highest percentage of degrees awarded was in chemical engineering.

A companion report including 69 institutions accredited as a whole by state or regional accrediting associations but which do not have curricula accredited by the ECPD will be published as Circular *516*, "Engineering Enrollments and Degrees, 1957," of the United States Department of Health, Education, and Welfare Office of Education.

Union College Professor To Serve on EJC Committee

H. W. Bibber (F '46), professor of electrical engineering at Union College, Schenectady, N. Y., has been named to the International Relations Committee of the Engineers Joint Council (EJC). He will represent on EJC the American Society for Engineering Education (ASEE), of which he has been an active member for the past 37 years.

An educator of long standing, Prof. Bibber served several terms as chairman of Union College's Division of Engineering and for 12 years as chairman of the department of electrical engineering. His teaching experience also includes 3 years at the Massachusetts Institute of Technology (his alma mater), a year at the École Centrale des Arts et Manufactures in Paris, France, and 11 years at Ohio State. He spent an additional 9 years with the General Electric Company, 4 of them in Japan.

Prof. Bibber is highly active in the AIEE and serves as chairman of the Schenectady Section. He also serves as chairman of the Committee on International Relations of the ASEE and as a member of numerous American and European professional organizations.

Alumnus Presents Gift to Pratt Engineering School

A. W. Peterson, president of the Continental Electric Company of Newark, N. J., has presented a check for $10,000 to the Engineering School of Pratt Institute, it was announced by Dr. R. F. Oxnam, president of Pratt, recently.

This gift establishes a loan fund which will be of help to many students who

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otherwise might be unable to complete their engineering education.

As an alumnus, Mr. Peterson is deeply appreciative of the technical training he got at Pratt Institute, which has made it possible for him to build a company employing over 400 men. He believes that Pratt has the advanced kind of engineering-science program which will prepare the talented young people of today for tomorrow's world of science.

Philadelphia Section Holds Successful "Students Night"

"Students Night" was the theme of the February Philadelphia Section dinner meeting attended by over 300. Almost 150 electrical engineering students from the junior classes of Drexel Institute of Technology, Princeton, Swarthmore, University of Pennsylvania, and Villanova were guests of the Section at the dinner.

Dr. Irven Travis, vice-president, research and engineering, Burroughs Corporation, spoke to the group on "Planning an Engineering Career." Dr. Travis stressed that it was highly desirable to obtain as much advanced technical training as possible inasmuch as this often permitted the engineer to work also in a different but related field. He urged the students not to limit their sights to just one job. After the formal portion of his talk, Dr. Travis answered a number of penetrating questions put forth by the students.

Dr. Travis, a graduate and former teacher at the University of Pennsylvania, was active in the development of the ENIAC and is credited wth development of the brain of the Air Force's "Atlas" missile.

AIEE–IRE Branch Honors Dr. Honnell

Student Members of the Joint AIEE–Institute of Radio Engineers (IRE) Branch at Washington University recently honored Prof. P. M. Honnell, with a banquet and the presentation of a plaque. While the occasion was initiated by the fact that Prof. Honnell has recently received triple honors—the Marconi Premium prize from The British Institution of Radio Engineers for the ". . . most outstanding paper of an engineering nature published in *Journal* (British IRE) during 1956," a fellowship in the AIEE for ". . . his contributions to electrical engineering in the fields of research and education," and a fellowship in IRE for ". . . distinguished teaching and research in applied electronics"—it was also to recognize his contributions to education in the electrical engineering department at Washington University, St. Louis, Mo., and his important fundamental researches which, as yet, have not received specific recognition generally. (For a biographical sketch of Prof. Honnell, see *Electrical Engineering*, February 1958, p. 177.)

The inscriptions on the plaque under the name Prof. P. M. Honnell, Ph.D., are in three groups. The first group consists of a flat-topped or "square" displacement wave with a velocity wave directly underneath. This is to give recognition to the work on "the prescribed function generator" or electromechanical "shaketable" with feedback control. The fact that an electronic oscillator can be made to produce essentially flat-topped or "square wave" time functions of voltage is not too surprising, but when a mechanical platform can be made to produce time functions of displacement essentially of the same character, those with appreciation of electromechanics will recognize a real achievement. In fact, the apparatus developed by Dr. Honnell will generate such sharp excursions that the table or plate will ring as though struck with a hammer. For the paper on this work he was awarded the Marconi Premium.

In the middle group is the inscription $A\ (\lambda) = O$ directing attention to Dr. Honnell's stability criterion which was stated in a *Transactions* paper in 1951 and has been the subject of a recent *Transactions* paper appearing in July 1957. This criterion is more general than the "Nyquist" criterion and permits "cutting" the network at points other than those of zero or infinite immittance. It also has more generality in that it can be used on systems constructed of bilateral elements. This has application in the field of servomechanisms among others and could result in new series of synthesis techniques.

The third group is an inscription of the ideograph of a synthesis network for programming analog computers which was developed by Dr. Honnell and one of his graduate students, Dr. R. E. Horn now of Westinghouse, and which appeared in the *Transactions* and *Electrical Engineering* in 1957. The advantage of a computer built as dictated by matrix methods and this ideograph would be its simplicity of problem synthesis or simulation and its systematic extension for problems of large dimensions.

The plaque was presented by Dr. R. J. W. Koopman, professor and head of the department of electrical engineering at Washington University. Dr. Koopman is also chairman of the St. Louis Section of AIEE, vice-chairman of the AIEE National Aircraft and Flight Test Instrumentation Committee, and member of the Education and Feedback Control Committees.

After the presentation, Dr. Honnell responded with a short but inspiring address on "Research—a Personal Adventure."

Among those present at the ceremonies were Robert Ozment, lecturer in electrical engineering and counselor of the IRE division of the Washington University AIEE–IRE Branch; Dr. Marvin Fisher, assistant professor of electrical engineering and counselor of the AIEE Student Branch at Washington University; Lee Gintz, chairman of the Student Branch; Dean Don Fischer, dean of the School of Engineering; and John Newell who was in charge of arrangements for the occasion.

DR. P. M. HONNELL *(right)*, **professor of electrical engineering, is presented with a plaque by Dr. R. J. W. Koopman** *(left)*, **head of the department of electrical engineering at Washington University, during a recent banquet of the AIEE–IRE Student Branch at the school located in St. Louis.**

OAS Announces Fellowship Program

On July 1, 1958, the Organization of American States (OAS) will begin an undertaking designed to help individual specialists as well as the OAS member states. A new fellowship program, recommended by the Inter-American Committee of Presidential Representatives, will enter into force on that date and will offer grants for advanced study or research to specialists throughout the Western Hemisphere. Qualified persons who are looking for an opportunity to do pure research, improve their professional skill

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through a postgraduate course, or enroll in an advanced technical course may apply now to the program. By offering advanced study abroad, the OAS hopes to increase the individual's contribution to his country of residence.

Interested persons should address their inquiries and requests for necessary forms to, Technical Secretary, OAS Fellowship Program, Pan American Union, Washington 6, D.C., USA.

Applicants will be screened by the OAS General Secretariat for technical or professional competence, including consultation with specialists in the given field. Awards will be made by the Secretary General of the OAS, taking into account the preferences expressed by the member states according to the fields of their most urgent needs, as well as the merits of each candidate. Over the years, the Secretary General will maintain a balance in the distribution between the number of fellowships available and the needs of the member states. Upon completion of their study, fellowship holders must return to their country of permanent residence.

According to the decisions taken by the OAS Council the program contemplates approximately 170 fellowships for 1958-59 and a minimum of 500 annually in the future. Grants will be made for periods ranging from three months to two years, covering such items as travel, registration and tuition fees, study or work materials, and room and board.

Dr. Javier Malagón has been appointed Technical Secretary of the Fellowship Program by the Secretary General of the OAS, Dr. J. A. Mora.

Clemson Establishes Student Broadcasting System

A closed-circuit broadcasting system has been approved for Clemson College by the Board of Trustees. Tentative date for the first broadcast is May 1.

The station, with studios on the third floor of the Student Center, will use the college electrical system for transmission to dormitories.

Music, national news and sports, and Clemson athletic events, will be featured with special educational programming planned. There will be no commercials. Estimated cost is $4,000 in initial expenditures and $650 annually for operation.

Establishment of the Student Broadcasting System, as it will be known, is the result of a joint student-administration research into cost, feasibility, and installations methods. Recommendations by a student survey team of Harry Bolick, Kinards, S. C.; Van Fair, Gastonia, N. C.; and David Suggs, Columbia, S. C., were unanimously accepted by an administrative committee, comprising Dean of Students Walter Cox; Henry Hill, director of auxiliary enterprises; Dr. G. E. Bair, professor of English; Dr. J. N. Thurston, head, department of electrical engineering, and L. A. Edwards, superintendent of buildings.

Mr. Fair will serve as engineering director; Mr. Suggs as program director and Mr. Bolick as business director and chairman of an all-student board of directors yet to be named. The station will carry an 8-member engineering staff and a 17-member program staff.

The station will be an entertainment service to students, a communications vehicle between students and the faculty and staff, and a training ground for students interested in the radio field.

MKS Symbols for Magnetic Materials and Catalogs

The mks (meter-kilogram-second) system is in widespread use in educational areas. The catalogs of most manufacturers of magnetic materials, however, did not use the mks system in the past and, hence, problems arose when students were exposed to a solution of practical problems using available commercial information. A. B. Rosenstein of the University of California at Los Angeles requested that manufacturers be approached by the Theory Subcommittee of the AIEE Magnetic Amplifiers Committee and be requested to present their data also in the mks system. As a result of Mr. Rosenstein's proposal, which was also supported by R. C. Barker of Yale and other educators, nine core manufacturers were approached on this subject. Answers were received from five manufacturers, ranging from declining to full adoption in at least one case, namely Magnetics, Inc.

Union College Alumnus To Return as Faculty Member

Union College alumnus D. A. Buddenhagen, currently an engineer with the Hughes Aircraft Company, Culver City, Calif., will return to Union this Fall as an assistant professor of electrical engineering. His appointment to the post, effective September 1st, was announced recently by Dr. Carter Davidson, president of the 162-year-old liberal arts and engineering college in Schenectady, N. Y. Mr. Buddenhagen, a native of Kingston, N. Y., was one of the top honor men in Union's Class of 1956.

MRI To Use Grant for Electronics Research

Polytechnic Institute of Brooklyn has been awarded a grant of $100,000 by the Joint Services Technical Advisory Committee to support basic research in the field of electronics, it was announced by Dr. Nathan Marcuvitz, director of Polytechnic's Microwave Research Institute (MRI).

Under the terms of the contract, the MRI will conduct exploratory research in fundamental microwave electron dynamics, nonlinear and information networks, and the interaction between electromagnetic fields and materials. The project will be a joint effort of MRI's research staff and faculty together with graduate students from the various departments of the Polytechnic.

A Joint Services contract is supported by all three military services through the Air Force Office of Scientific Research, the Office of Naval Research, and the U.S. Army Signal Engineering Laboratories.

Polytechnic is one of five institutions in the United States which have been awarded such contracts. The others are Columbia University, Harvard University, Massachusetts Institute of Technology, and Stanford University.

Summer Program in Nuclear Energy for Industry

The Third Annual Summer Program in "Nuclear Energy for Industry" will be held on the Berkeley campus of the University of California during the months of June, July, and August 1958.

An intensive 9-week "Nuclear Engineering Short Course" for engineers and other technical personnel begins June 16.

"Nuclear Engineering Survey," a program to acquaint executives and administrators with the nontechnical aspects of nuclear science and show how it can be applied in industry, will be given during the week of July 7.

Both programs are presented by Engineering and Sciences Extension and will make use of University laboratory facilities. Field trips to the UC Radiation Laboratory and other installations in the Bay Area are being planned, and leading scientists, engineers, and businessmen will participate as lecturers.

The tuition for the nuclear engineering course is $800. The fee for the nontechnical survey program is $150.

Further information and application for enrollment may be obtained from Engineering and Sciences Extension, Room 100, Building T-11, University of California, Berkeley 4, Calif.

Sixth Session Underway at Argonne International School

Nearly 70 scientists and engineers from throughout the free world began a semester of classroom and laboratory training, February 4, at the sixth session of the International School of Nuclear Science and Engineering at Argonne National Laboratory, Lemont, Ill.

Their training program, a continuing part of President Eisenhower's "Atoms for Peace" project, is conducted by the U.S. Atomic Energy Commission (AEC). Most of the scientists and engineers already have completed a semester of studies at either North Carolina State College, Raleigh, N.C., or Pennsylvania State University, State College, Pa.

Nuclear reactors, their design, construction, instrumentation, and use, are the

principal subjects of the unclassified course. Sixth session enrollment will bring to more than 350 the number of scientists and engineers who have received International School training. As the session began, a new group of scientists and engineers started training at the two co-operating universities. These will attend Argonne in June 1958.

In coming to Argonne, the sixth session participants toured atomic energy installations in the eastern United States. Among facilities they visited were Oak Ridge National Laboratory, Tenn.; the Detroit Edison atomic power reactor development and planning center; nuclear laboratories at the University of Michigan; and the Shippingport, Pa., pressurized water reactor operated by the Duquesne Power and Light Co. At the end of their course, they will tour western atomic energy facilities.

Enrollment for the sixth session of the International School totals 55 scientists and engineers from 22 foreign countries and 11 from the United States. Most of the American participants are sponsored by private firms interested in nuclear energy; foreign participants were largely selected by atomic energy commissions in their home countries, although some come from universities and industry.

International School training at Argonne is divided into two periods. Following six weeks of formal instruction, the scientists and engineers spend the remainder of their time at the Laboratory conducting individual research projects. Although primarily concerned with nuclear reactors, the Argonne course includes other areas of study also important in the putting to use of nuclear energy for peaceful purposes.

The laboratory work performed includes procedures which are basic to the entire reactor technology for large-scale experiments in reactor engineering and in preparation and reprocessing of reactor fuel. Opportunity is available for those who wish training in the techniques of nuclear research in nuclear chemistry and physics and in nuclear engineering.

Participants at the International School operate and perform experiments with the Argonaut, Argonne's low-power reactor designed primarily for training. For certain experiments, they utilize Chicago Pile 5, the Laboratory's principal reactor for scientific research. They use Argonne's "caves" for experiments which involve highly radioactive materials.

The Argonne solvent extraction separation facility is used by participants studying the separation of fertile and fissionable material from atomic wastes. A heat transfer unit is available to the participants to study the heat transfer and flow characteristics of sodium-potassium alloy, a liquid metal, at room temperature.

Equipment available to the participants for nuclear physics studies include three exponential assemblies, or subcritical reactors. These are composed of natural uranium rods arranged so that a self-sustaining chain reaction will not take place.

In describing the School, Dr. R. G. Taecker, director of the International School, said:

"The curriculum is designed to give a broad understanding of the basic principles which will enable the participants to perform intelligently in reactor science, engineering, and allied technologies. The School does not restrict participants to a rigid program of study. With the knowledge and experience which the instructors are able to contribute, the participant is prepared to face the myriad problems associated with design, operation, and use of reactors and to make significant contributions within his own field of specialization."

United States Exchange Program Marks 10th Year

Nearly 50,000 persons have benefited by the provisions of the United States Information and Educational Exchange Act of 1948 during the decade that it has been in operation. Sponsored by Sen. H. A. Smith and Rep. (now Senator) K. E. Mundt, this act became effective 10 years ago on January 27, creating permanent authority for a global program of international exchanges, administered by the Department of State.

The Smith–Mundt Act, as it has come to be known, has made possible the exchange of 14,000 Americans and 36,000 foreign nationals from more than 80 countries. Of these, the largest number (24,000) were graduate students. The program brought more than 10,000 specialists and leaders from other nations to the United States for study or training. It also permitted visits by 6,000 teachers,

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Lamar State College of Technology

THE AIEE Student Affiliate Branch was established at Lamar State College of Technology, Beaumont, Texas, in 1955 (see p. 431). Student Officers and professors shown above, left, are: (*left to right*) Mrs. Mary Politz, vice-chairman, AIEE Student Affiliate Branch; Loyd Hopkins (seated), chairman; Kenneth Moore, secretary, IRE; Charles Scott, secretary, AIEE; Prof. L. B. Cherry, head, department of electrical engineering, and member of the National Student Branches Committee of AIEE; and Asst. Prof. J. L. Cooke, Branch counselor. Lamar State College is supported by the State of Texas and is located in one of the largest industrial areas of the State. Its present plant is valued at $7.5 million and definite plans have been made to enlarge it by $5 million within the next five years. *Above, right:* Students engage in laboratory experiments. The electrical engineering laboratories are housed in one wing of the new Engineering Building which was completed in 1951, the year that the College was established.

Courtesy Christopher Studio

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7,000 university lecturers, and some 1,000 teen-agers.

In addition to administering these Government-sponsored exchanges, the State Department has also assisted privately sponsored exchanges involving approximately 6,000 persons annually. It has, under the authority of the Smith-Mundt Act, facilitated the entry of nearly 50,000 persons into this country for educational purposes. This private-official co-operation to develop greater mutual understanding between America and her world neighbors has been enhanced by significant contributions in finances and services by many private organizations and institutions.

Plastic Models Available for School Use

A new and unusual line of clear plastic mathematical and mechanical models for use in high schools and colleges has been announced by Physics Research Laboratories, Inc., of Hempstead, N. Y., importers of high precision laboratory equipment.

For the first time, the student can see not only plane geometry brought to life but also the more difficult spatial visualizations of solid geometry, descriptive geometry, mechanical drawing, and analytical mechanics. With the increased emphasis on the teaching of mathematics, these models offer schools, teachers, and students in the United States the same tools which have proved so useful in Germany and other European countries. The inability to "see" space relationships can be completely eliminated with these models.

ONE OF A NEW LINE of clear plastic mathematical and mechanical models for use in high schools and colleges.

They are available in hundreds of configurations, either singly or in integrated sets. Their cost is moderate, their accuracy high, and their adaptability unlimited. Address inquiries to Physics Research Laboratories Inc., P. O. Box 555, Hempstead, N. Y.

Gordon Research Conferences for 1958

The Gordon Research Conferences for 1958 will be held from June 9 to August 29 at Colby Junior College, New London, N. H.; New Hampton School, New Hampton, N. H.; and Kimball Union Academy, Meriden, N. H.

The Conferences were established to stimulate research in universities, research foundations, and industrial laboratories. This purpose is achieved by an informal type of meeting consisting of scheduled lectures and free discussion groups. Sufficient time is available to stimulate informal discussions among the members of a Conference. Meetings are held in the morning and in the evening, Monday through Friday, with the exception of Friday evening. The afternoons are available for participation in discussion groups as the individual desires. This type of meeting is a valuable means of disseminating information and ideas which otherwise would not be realized through the normal channels of publication and scientific meetings. In addition, scientists in related fields become acquainted and valuable associations are formed which result in collaboration and co-operative effort between different laboratories.

It is hoped that each Conference will extend the frontiers of science by fostering a free and informal exchange of ideas between persons actively interested in the subjects under discussion. The purpose of the program is not to review the known fields of chemistry but primarily to bring experts up to date as to the latest developments, to analyze the significance of these developments, and to provoke suggestions as to underlying theories and profitable methods of approach for making new progress. In order to protect individual rights and to promote discussion, it is an established rule of each Conference that all information presented is not to be used without specific authorization of the individual making the contribution, whether in formal presentation or in discussion. No publications are prepared as emanating from the Conferences.

Individuals interested in attending a Conference are requested to send their applications to the director. Each applicant must state the institution or company with which he is connected and the type of work in which he is most interested. Attendance at each Conference is limited to 100.

The complete program of the Conferences was published in *Science*, February 28, 1958.

Requests for attendance at the Conferences, or for any additional information, should be addressed to W. G. Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, R. I. From June 9 to August 29, 1958, mail should be addressed to Colby Junior College, New London, N. H.

The Gordon Research Conference on Physical Metallurgy, to be held at the New Hampton School, New Hampton, N. H., June 9-13, 1958, will center around the topic "Microstructures: Their Origin and Influence on Properties." There will be sessions on: special techniques, dislocations studies, precipitation and second phases, deformation and fracture, and oxidation and corrosion.

Penn State Offers Technical Writing Seminar

The Pennsylvania State University will conduct the 4th Annual Technical Report Writing Seminar September 14-26, 1958, at University Park, Pa.

The workshop will provide scientists and engineers with practical instruction and supervised practice in the preparation of effective technical reports, and offer comprehensive refresher training to technical writers and editors. Enrollment is limited to 40 persons to make individual instruction possible.

C. K. Arnold, associate professor of engineering research and staff assistant to the president at Penn State, is chairman for the event. Other staff members will include Dr. D. E. Gray, program director for Government research information, National Science Foundation; and A. G. Norris, director of technical information, Vitro Engineering Division, the Vitro Corporation of America.

Morning lectures will include discussion of characteristics of good technical writing and methods of achieving them, a review of the mechanics of writing, discussion of the organization of a report and of each of its components, and the use of such graphic aids as photographs, tables, charts, and graphs.

Afternoon sessions will be devoted to actual writing in which the principles and procedures developed in the morning session can be applied to the completion of concrete assignments. Each registrant will be asked to bring a writing project with him to make the workshop sessions as meaningful as possible.

Further information is available by writing the Extension Conference Center, The Pennsylvania State University, University Park, Pa.

Construction Program at Fenn College Accelerated

Fenn College trustees have authorized acceleration of a $4 million construction program originally planned in two steps. Conversion of the former Ohio Motors building on E. 24th St., Cleveland, Ohio, will proceed immediately. It will be completed by the Fall of 1959, in time to accommodate the coming enrollment increase.

Two considerations influenced the trustees' decision to begin the entire project now, Pres. G. B. Earnest said. These

were: the nation's competitive need for more scientists, engineers, and men and women trained in the liberal arts and business fields; and the consequent need for improved and expanded teaching facilities by Fall of 1959, when the fringe of the enrollment bulge will hit Fenn.

"We are taking this bold step now," C. J. Stilwell, chairman of the Board of Trustees said, "because it is our responsibility as trustees to make higher education available to those qualified students who will be coming to us. So we are building now, after the first year of our three-year capital development program."

To date, the College has raised $2.5 million in grants from Cleveland business and industry, trustees, alumni, and individuals.

The remodeled building, provisionally renamed the West Campus Building, will give Fenn the equivalent of at least four buildings on most campuses. The College's instructional plant will be doubled. The new library will more than double the seating capacity of the old, while tripling its collection of approximately 37,000 volumes. The new construction will provide fully equipped laboratories in chemical, civil, electrical, mechanical, and metallurgical engineering; and in anatomy, bacteriology, biology, chemistry, nursing science, physics, and physiology.

The Fenn College registrar's office estimates that, with the West Campus Building, the College can accommodate a 2,500 day division enrollment and a 7,500 evening division enrollment.

Special Summer Program in Switching Circuits at MIT

To promote more widespread understanding and more effective application of the principles underlying the design of switching circuits, the Massachusetts Institute of Technology (MIT) will offer during the 1958 Summer Session a two-week Special Summer Program in Switching Circuits, June 17-27, 1958.

This special summer program is planned for engineers and research workers engaged in the development of equipment using switching circuits, and for teachers who plan to offer courses in switching circuits. No previous experience with the mathematical aspects of switching circuits will be required. The tuition is $250, due and payable upon notification of admission. Academic credit is not offered.

Approximately half of the program will be devoted to lectures which amplify and supplement the textbook material. In the remaining time, smaller groups will be formed for the discussion and solution of specific problems in various areas.

The topics to be discussed in lectures include: switching algebra; algebraic treatment of contact networks; minimization methods; algebraic treatment of nonrelay elements, including electron tubes, semiconductor devices, and magnetic cores; multiple output networks; symmetric and iterative circuits; sequential circuit synthesis; pulsed circuits; hazards in circuit synthesis.

Lectures will be given daily, except Saturday, from 9:30 to 11:30 a.m. The problem study groups will meet from 1:30 to 4:00 p.m. Laboratory facilities will be available for those who prefer to use some time for experiments.

The program will be under the supervision of Dr. S. H. Caldwell, professor of electrical engineering, assisted by members of the staff of the department of electrical engineering.

Graduate Study Program in Nuclear Science at Clemson

Graduate study leading to a master of science degree in nuclear science was announced recently by Clemson College, Clemson, S. C.

The new, forward-looking program, endorsed by the educational council, became effective February 1. It is the first graduate work in nuclear studies being offered in South Carolina.

Dr. Jack Williams, acting dean of the Clemson Graduate School, said course work would comprise chemistry, mathematics, and physics and that thesis research would be done in the Du Pont Laboratories of the Savannah River Atomic Energy Commission Operations Plant at Aiken, Ga.

First candidates for the degree began work in the second semester at Clemson. Additional students will be accepted, beginning with the summer session in June 1958 and the fall semester in September 1958.

Enrollment will be limited, Dr. Williams stated, and only college graduates in chemistry, mathematics, and physics are eligible to apply. Additional candidates, he indicated, may qualify with undergraduate engineering backgrounds.

The degree will require six semester hours of advanced calculus, four hours of nuclear physics, three hours of reactor theory, six hours of chemistry, mathematics, and physics, and six hours of directed research culminating in a thesis report.

Attractive teaching and research assistantships are provided.

Information on the fundamental courses and electives, financial aid and entrance is being made available by the dean's office at Clemson College on request.

Short Course in Operations Research at Case

The Operations Research Group at Case Institute of Technology will offer a Short Course in Operations Research in Production and Inventory Control June 2-13, 1958.

For information concerning the course, write to: Louise Reed, Secretary, Operations Research Group, Case Institute of Technology, University Circle, Cleveland 6, Ohio.

Electrical Engineering Education

Facility for Thermonuclear Research

AN ARCHITECTURAL RENDERING of the Model C Stellarator Project at Princeton University is shown. Scheduled for completion about 1960, scientists will conduct research on controlled thermonuclear reactions here. The master plan for the project was developed by Walter Kidde Constructors, Inc. (Kidde), engineers and builders, New York, N.Y., and Houston, Texas, under a contract awarded in 1957. Under the same contract, Kidde has completed engineering design of the office building and laboratory (structures in the foreground of the rendering) and the boiler house and other service facilities. The rendering indicates approximate size and location of these two structures (in the top part of the photo) but does not attempt to depict actual design.

Electrical Engineering Education

Advisory Committee on Nuclear Engineering at LTI

Appointment of six men to the advisory committee on nuclear engineering at Lowell Technological Institute (LTI) has been announced by Dr. M. J. Lydon, president. They will act as consultants on this new program to be established in September 1958 at LTI, first of its kind in a publicly supported educational institution in New England.

The committee will include Dr. B. H. Billings, vice-president, Baird-Atomic, Inc., Cambridge, Mass.; R. J. Coe, vice-president, Yankee Atomic Electric Company, Boston, Mass.; Dr. C. D. Goodman, assistant director for technical operations, Division of Reactor Development, U. S. Atomic Energy Commission, Washington, D. C.; Dr. T. H. Johnson, vice-president and manager of research, Raytheon Manufacturing Company, Waltham, Mass.; Dr. A. R. Kaufmann, vice-president and technical director, Nuclear Metals, Inc., Cambridge; and Dr. M. G. Schorr, executive vice-president and treasurer, Technical Operations, Inc., Burlington.

The nuclear program at LTI will have as its eventual objective the training of nuclear scientists on the graduate level, nuclear engineers on the undergraduate level, and nuclear technicians on the associate-degree level. The undergraduate program only will be inaugurated in the Fall of this year with the purpose of educating both nuclear engineers and nuclear chemists.

This advisory committee is similar to those already functioning as consultive bodies at LTI for the electronics, plastics, leather, paper, and textile courses.

American Viscose Program of Aid-to-Education, 1958-59

Some 78 colleges and universities will benefit next year from the aid-to-education program of American Viscose Corporation. In announcing the plans for the 1958-59 academic year, H. H. Bitler, vice-president, declared, "We take pride in our continued association with the many American business organizations that are aware of the increasing importance of industry participation in the future of education. As in previous years," he stated, "the program includes scholarships, fellowships, grants-in-aid, and assistance through educational foundations."

American Viscose Corporation's program is designed to aid educational institutions in their over-all programs and encourage the study of science and engineering. The recipients of the scholarships and fellowships are selected by the schools on the basis of scholastic merit and need. American Viscose takes no part in this selection, nor are the students under any obligation to the corporation.

Scholarships valued at $500 each have been awarded for undergraduates who are majoring in chemistry, physics, engineering, textiles, and business administration. Fellowships for graduate work, ranging from $1,700 to $2,800, have been established in the fields of chemistry, chemical engineering, and cellulose chemistry. Grants-in-aid have been awarded for research in fields of packaging films and textile fibers in addition to the general fields covered in scholarships and fellowships.

The following institutions have been invited to take part in the program during the 1958-59 academic year: Allegheny College, Carnegie Institute of Technology, Clemson Agricultural College, Cornell University, University of Delaware, Drexel Institute of Technology, Georgia Institute of Technology, Jefferson Medical College, Lehigh University, Mary Washington College, Massachusetts Institute of Technology, McGill University, Morris Harvey College, North Carolina State College, University of North Carolina, Pennsylvania Foundation for Independent Colleges, Pennsylvania State University, University of Pennsylvania, Philadelphia Textile Institute, Princeton Textile Research Institute, Purdue University Roanoke College, University of Rochester, Rose Polytechnic Institute, Virginia Foundation for Independent Colleges, Virginia Polytechnic Institute, West Virginia Foundation for Independent Colleges, West Virginia University, and Yale University.

Intensive Courses in Industrial Engineering

For the first time anywhere, eight complete Basic Industrial Engineering Intensive Courses will be offered concurrently at Washington University, St. Louis, Mo. Students from different courses will be able to intermingle at off hours to exchange experiences and instructors from various courses will be available for discussion. An enrolee stays in *one* intensive course during the entire two week period.

The following intensive courses will be offered: Quality Control, Psychological Engineering, Motion and Time Study, Collective Bargaining for Engineers*, Elements of Integrated Data Processing, Engineering Economy, Materials and Process of Manufacturing*, Tool Engineering, Plant Layout and Materials Handling, Production Control. (*Two topics presented, one week each, in the two-week period.)

These basic Industrial Engineering Intensive Courses are being offered by the department of industrial engineering and the University College at Washington University September 8-19, 1958. They are intended for personnel desiring a basic introduction to the subject of the course. Material covered will be presented with emphasis on gaining fundamentals of the area. The objectives of the courses will be to help prepare the attendee to (1) apply the course concepts in his own organization, and (2) help train others in his company in the principles of his course.

The entire series will be presented at a resort in the Ozarks. Recreational facilities will be available to all attendees during the off hours of the courses, and during the one week-end at the resort. Members of the intensive course teaching staff include industrial personnel as well as Washington University and other university faculty who are experts in their particular field. One general session a day will be devoted to topics of interest to all intensive course enrollees; speakers selected from among the instructors will present their experiences with related fields in industry.

These courses are being presented with the co-operation of the St. Louis chapters of the American Institute of Industrial Engineers, The American Society of Mechanical Engineers, American Society of Tool Engineers, American Society for Quality Control, American Materials Handling Society, Association for Computing Machinery, and Society for Advancement of Management. For further information concerning course contents, instructors, and registration, write to University College, Washington University, St. Louis 5, Mo.

Colorado School of Mines "Mineral Industries Bulletin"

A new publication covering the field of Colorado's minerals has been published by the Colorado School of Mines. Called "Mineral Industries Bulletin," the bi-monthly publication deals with important minerals native to Colorado and their respective uses in industry.

The first issue of "Mineral Industries Bulletin" treated the metallic element beryllium and was written by D. R. Williamson, project engineer at the Colorado School of Mines Research Foundation. This new series of bulletins is a joint venture by the Colorado School of Mines and the Research Foundation. The second issue, published in March, treated lithium and its uses, and future bulletins on clay and titanium are planned. The "Mineral Industries Bulletin" (which will be sent free of charge to those people who request it from the Department of Publications, the Colorado School of Mines) is intended to supply current information to those people interested in the mineral industry potential of the State of Colorado. They will contain articles and statistics regarding the elements of Colorado's geology and mineral resources, mining operations, metal markets, production statistics, economics, and other aspects of Colorado's mineral industries.

The first issue contains classification charts, geological surveys of occurrences, extractive metallurgy process explanations, a map of Colorado which designates precambrian pegmatite districts and a selected bibliography of articles pertaining to beryllium. Beryllium, the major use of which now is in the production of alloys, occurs as a major constituent in some of Colorado's minerals.

INSTITUTE ACTIVITIES

National Telemetering Conference To Be Held in Baltimore, June 2-4, 1958

THE 1958 National Telemetering Conference will be held June 2-4 at the Lord Baltimore Hotel, Baltimore, Md. It is being sponsored by the AIEE, the American Rocket Society (ARS), the Instrument Society of America (ISA), and the Institute of Aeronautical Sciences (IAS), and is supported by the National Academy of Sciences and the U.S. Armed Forces. The program will include sessions on systems, data processing, components, and equipment, and research associated with oceanography, astronomy, cosmic ray studies, and rocketry.

Registration

Registration facilities will be open on Sunday, June 1 and throughout the day on Monday, Tuesday, and Wednesday.

The registration fee covers unlimited access to the technical sessions and to the exhibits.

Advance registration will prevent disappointments as the inspection trip to Aberdeen Proving Ground is limited to 120 persons, the Martin Company trip to 150, the Applied Physics Laboratory trip to 75, and the Banquet to 550.

Full details of the Conference and advance registration forms may be obtained by writing to: E. T. Loane, C. & P. Telephone Company of Maryland, 320 St. Paul Place, Baltimore 2, Md.

Exhibits

Leading manufacturers in the telemetering field will show and demonstrate their latest equipment. Many of the exhibits will tie in with the technical papers which will provide an opportunity, both to see the equipment and to hear how it is used. This will offer a convenient means of keeping informed on the fast-moving telemetering field.

Inspection Trips

There will be three inspection trips. On the afternoon of June 3, the Applied Physics Laboratory will be visited. Here will be seen the TERRIER and TALOS missiles and the telemetering ground station used for checking and experimental work. This trip will be limited to 75 people.

An all-day trip is planned for June 4 to the Aberdeen Proving Ground's Ballistic Research Laboratory where visitors may inspect the wind tunnel, IGY rockets, and the most complete ordnance museum in this country. This will be restricted to 120 people leaving Baltimore at 9 a.m. and returning at 4 p.m.

Also on June 4, an evening trip has been scheduled to the Martin Company—prime contractor for the Vanguard rocket. It is planned to view the extensive telemeter receiving and data processing system for flight testing. The trip has been limited to 150 people.

Entertainment

On Monday evening, June 2, there will be a twilight trip over the famed Chesapeake Bay Bridge (an awe inspiring sight) to the historic Eastern Shore country of Maryland, where dinner will be served in traditional style. Of course, the ladies are expected to attend.

On Tuesday evening, there will be a Banquet at the Lord Baltimore Hotel to which the ladies are also invited.

Ladies Program

Special emphasis will be placed on attracting the wives of registrants and an interesting program has been arranged for their pleasure.

On Monday, there will be a coffee hour followed by a luncheon in the Party Room of a leading department store. The afternoon will be free for shopping.

Tuesday will get under way with a coffee hour in the morning and a visit in the

TALOS, a surface-to-air guided missile, is shown above being boosted to supersonic speed from its launching site at the White Sands Proving Ground. This missile, soon to become operational, was developed for the Navy's Bureau of Ordnance under the direction of the Johns Hopkins University, Applied Physics Laboratory. Telemetered information from the missile to a receiving and recording station of the type shown below has made possible in-flight confirmation of performance and the feasibility of designs. Telemetering in missiles and industry will be discussed at the National Telemetering Conference to be held on June 2-4, 1958, in Baltimore, Md.

afternoon to the famous McCormick's "House of Spices."

On Wednesday there will be the usual coffee hour in the morning, followed by a luncheon and Fashion Show at the Green Spring Inn. There will be a bus tour of the Baltimore residential areas en route to the Inn.

High Lights

Don't miss the Monday Luncheon, during which Gen Earle Cook, U. S. Army Signal Engineering Laboratory, Fort Monmouth, N. J., will speak on the telemetering requirements of the U. S. Army.

The Tuesday Luncheon will be highlighted by Adm. Gordon Caswell, USN, retired, who will speak on problems of international frequency allocation.

On Tuesday evening, the Banquet speaker will be Adm. Blinn Van Mater who will discuss telemetering in the IGY.

There will be an international flavor to this year's Conference with papers from France, Canada, Sweden, Switzerland, Australia, Italy, Great Britain, and USSR. The latter has been invited to attend and is expected to present several papers—this has been cleared by the State Department.

Technical Program

Advance copies of papers are not available; however, the Conference proceedings containing the majority of the papers will be available on June 2.

The tentative technical program will be as follows:

Sunday, June 1

Registration—Lord Baltimore Hotel

Monday, June 2

Morning Sessions

Industrial Telemetering I

Chairman: W. E. Rufleth, Bristol Company

Telemetering for Automatic Pipelines. *F. V. Long*, Texas Eastern Transmission Corporation

A Noise-Operated Squelch Device for Microwave Radio Receiver. *E. A. Cockey, C. J. Stump*, Baltimore Gas & Electric Company

Diagrammatic Methods of Code Construction. *R. C. Clark*, General Electric Company

Audio Tone Control in Gas Distribution. *Menkes* and *Propper*, Hammarlund Manufacturing Company, Inc.

Two-Frequency In-Plant Carrier Telemetering System. *F. W. Petit, E. P. I. Schultz*, Bristol Company

Pickups

Chairman: W. Wildhack, National Bureau of Standards

Absolute Calibration of a Capacitance-Type Vibration Pickup. *W. Koidan*, National Bureau of Standards

An Electronic Pressure Gauge for Missile Telemetering. *W. L. Schwartz*, Litton Industries

Thermistor Probes for Missile Applications. *E. L. Johnson, Jr.*, Bendix Friez Instrument Division

Telemetering Transducer Program at NBS. *E. C. Lloyd, R. O. Smith*, National Bureau of Standards

On Some Grounding Problems in Low-Level Instrumentation. *J. C. Crosby*, Consolidated Electrodynamics

Mobile Airborne I

Chairman: G. P. Stout, Aeronca

A Six-Channel Airborne Strain Gage Calibrator and D-C Excitation. *R. H. Gablehouse, C. E. Erickson*, Sandia Corporation

Printed Circuit Packaging for Environmental Extremes. *W. A. Corry*, Radiation, Inc.

Airborne VHF Power Amplifier. *W. H. Swain*, Electro-Mechanical Research, Inc.

Voltage Monitor. G. M. Giannini & Co., Inc.

Miniature High Performance FM Receivers for Telemetry and Command Guidance. *C. Rosen*, Tele-Dynamics, Inc.

Telemetering and Data Processing in an Expendable Wind Sensing Instrument. *L. J. Rossbach, T. B. Smith*, Allied Research Associates

Luncheon

Address: Gen. Earle Cook, director, U. S. Army Signal Engineering Laboratories, "Telemetering Requirements of the U. S. Army"

Afternoon Sessions

Industrial Telemetering II

Chairman: W. E. Phillips, Leeds & Northrup Company

Five Years of Research on Telemetering by the Electrical Measurements Laboratory of the University of Bologna. *V. Modoni*, University of Bologna, Italy

A Current Balance Telemetering Transmitter for Pilot Wire Applications. *T. Barabutes*, Westinghouse Electric Corporation

Introduction of Supervisory Control into a Pulse Telemetering Time Division Multiplex System. *W. E. Rußeth*, Bristol Company

A Telemetering System of High Accuracy by Vernier Methods. *G. M. Keyser*, The Hydro-Electric Power Commission of Ontario

Medical

Chairman: Lt. Comdr. B. Halstead (MC) USN, Bethesda Naval Hospital

The Dynograph. *F. F. Offner*, Offner Electronics, Inc.

The Monitoring and Recording of Physiological Variables during Intra-Cardiac Surgery Using Extracorporeal Circulation. *W. F. Sutterer, E. H. Wood*, Mayo Clinic

Biologic and Physiologic Telemetering Applications. *D. Marken*, University of Rochester, School of Medicine and Dentistry.

Telemetering in Medical Operations. *R. Bowman*, National Institute of Health.

Telemetering in Aortic Measurements. *J. W. Still*, George Washington University, School of Medicine

The Endoradiosonde. *B. Jacobson*, Karolinska Institute, Sweden

Mobile Airborne II

Chairman: J. P. Randolph, Applied Physics Laboratory, The Johns Hopkins University

The Evaluation and Prediction of Circuit Performance by Statistical Techniques. *J. Marini, R. T. Williams*, Aeronautical Radio, Inc.

An 85-Mc FM Telemetering Transmitter. *J. F. Lawrence*, Ralph M. Parsons Company

A Subcarrier Oscillator Calibrator. *R. I. Anderson*, Wayne D. Patterson Company

A Precision Calibrator for PDM Telemeters. *H. J. Wood, Jr.*, White Sands Proving Ground

The Terminal Ballistics Altitude Indicator. *F. J. Enge*, American Machine and Foundry Company

Temperature Considerations in Missile Telemetry Packaging. *W. R. Wilson*, Texas Instruments, Inc.

Tuesday, June 3

Morning Sessions

IGY I

Chairman: H. Odishaw, National Academy of Sciences

Bathymetry Telemetry. *J. M. Snodgrass*, Scripps Institute of Oceanography, University of California

Microlock System. *W. C. Pilkington*, JPL California Institute of Technology

Instrumentation for Measuring Heavy Primary Cosmic Ray Flux in an Earth Satellite. *H. Pinckernell, L. Wilkes, E. Ruhstrad;* The Martin Company; *H. Hanson*, Rias, Inc.

Underwater-Acoustic Telemetering. *W. C. Beckman*, Lamont Geological Observatory, Columbia University

Telemetering from Small Research Rockets. *Bettinger, Elton, Singer*, University of Maryland, department of physics

Data Processing I

Chairman: K. Uglow, Ken Uglow, Inc.

Use of an Analog Computer in Evaluating Telemetered Information. *K. S. Bonwit*, Applied Physics Laboratory, The Johns Hopkins University

A Technique and Equipment for Rapid Measurement of Error in Missile Data Recovery. *R. S. Bark, I. Lantor*, Boeing Airplane Company

An Automatic Processing System for Telemetry Data. *G. E. Barlow*, Australian Department of Supply

MARTIN COMPANY'S Home Office—prime contractor for the Vanguard rocket. These plant facilities house the rocket assembly line of the Vanguard.

Automatic Digital Recording and Reduction for Telemetered Data. *J. J. Fleming*, U. S. Naval Research Laboratory

Design of Analog Filters for Telemetry Equipment. *G. Martin*, Data-Control Systems, Inc.

Luncheon

Address: Adm. Gordon Caswell, USN retired, "Problems of International Frequency Allocation"

IGY II

Chairman: Adm. Gordon Caswell, USN retired

Cosmic Ray Telemetering. *M. A. Pomerantz*, Bartol Research Foundation, The Franklin Institute

Radiation Balance Instrumentation for Satellite. *V. E. Suomi*, University of Wisconsin, department of meteorology.

Differential Magnetograph. *J. H. Nelson*, U. S. Department of Commerce, Coast and Geodetic Survey

IGY Rocket Telemetering. *L. G. DeBey*, Army Ordnance, Ballistics Research Laboratory

Data Processing II

Chairman: A. Gruer, Sandia Corporation

A Critique of Quick-Look Recording Devices. *R. C. Barto*, White Sands Proving Ground

A New Graphical Format—EDVAP. *J. D. Perdue*, White Sands Proving Ground

A Comparison of FM Demodulation Techniques. *R. A. Runyan*, Data-Control Systems, Inc.

A Range Time Decoder. *H. A. Kirsch*, The Ramo-Wooldridge Corporation

Magnetic Recording. Reeves Soundcraft Corporation

Evening—Banquet

Welcome: G. M. Thynell, chairman National Telemetering Conference 1958, Applied Physics Laboratory, The Johns Hopkins University

Address: Adm. Blinn Van Mater, USN retired, "Telemetering in the IGY"

Wednesday, June 4

Morning Sessions

Transistors

Chairman: F. Coker, United Electrodynamics

Transistorized Current-Controlled Oscillator for D-C Excited Strain Gage Applications. *C. E. Land*, Sandia Corporation

Thermocouple Differential Amplifier. *F. Hilsemath*, Lockheed Aircraft Corporation

A Transistorized FM Telemetering Transmitter. *R. O. Ireland, A. E. Beshore*, United Electrodynamics

Universal Telemetry Transmitter. *R. I. Jearley, Jr.*, Texas Instruments, Inc.

Transistor Airborne PDM System. *D. A. Williams, Jr.*, Bendix Aviation Corporation

A Transistorized Telemetering Commutator for Data Transmission. *Keats, Pullen, C. E. Shafer*, U. S. Army Ordnance Ballistics Research Laboratory

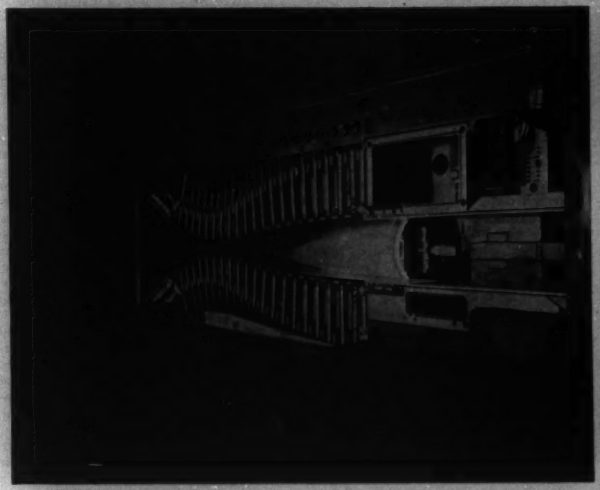
Mobile Systems I

Chairman: K. E. V. Willis, British Joint Service Mission

Some Aspects of Common-Mode Rejection as Applied to Telemetry Systems. *G. E. Bradford, E. L. Cox*, Radiation, Inc.

Spectral Characteristics of PAM Time-Division Multiplex Signals. *J. J. Downing*, Lockheed Aircraft Corporation

A Pressurized Telemetry Package for the ICBM Program. *G. E. Tisdale*, Electro-Mechanical Research, Inc.



ABERDEEN PROVING GROUND Ballistic Research Laboratory's Mach 5, 13- by 15-inch supersonic flexible nozzle wind tunnel with side wall removed. Flexible plates are positioned by means of jacks operated hydraulically. Typical calibration device is shown installed in the test section.

High Acceleration Telemetry. *T. D. Homing*, Bendix Aviation Corporation, Pacific Division

ONERA Telemetering System. *M. Roy*, Office Nationale D'Etudes et De Recherches Aeronautiques, France

Temperature Considerations in Missile Telemetry Packaging. *W. R. Wilson*, Bendix Aviation Corporation, Pacific Division

Mobile Ground

Chairman: W. J. Mayo-Wells, consultant

Use of an Airborne Receiving Station for Flight Test Telemetering. *A. C. Planitz*, Republic Aviation

An Application of Coherent Detection to Electronic Trajectory Measurement. *B. J. Weston*, Sandia Corporation

FM/FM Demodulation. *H. Scharla-Nielsen, D. D. McRae*, Radiation, Inc.

Antennas with Periodic and Pseudo Frequency Independent Performance. *D. E. Isbell, R. L. Carrel, P. E. Mayes*, University of Illinois, College of Engineering

The Range Resolver: A Device for Extending the Resolution of FM Telemeter Systems. *J. Riley*, Lockheed Aircraft Corporation

Holloman High-Speed Missile Test Track Telemetering. *D. H. Vleek*, ARDC, Holloman AFB

Afternoon Sessions

System Problems

Chairman: L. Gardenhire, Radiation, Inc.

Discussion Session

Mobile Systems II

Chairman: L. Clark, Tele-Dynamics, Inc.

Analysis of Interference in a Missile Telemetering System. *A. L. Albin, L. Milton*, Filtron Co., Inc.

Time Division Pulse Width Modulation—A New Approach to High Precision Telemetry. *J. J. Grossman*, Ralph M. Parsons Co.

An Advanced High-Level Instrumentation System for Missile Applications. *G. DuBoise*, Temco Aircraft Corporation, *J. H. Smith*, Texas Instruments, Inc.

PCM Data Acquisition. *R. Gerard*, EPSCO, Inc.

Advanced Techniques of Data Acquisition. *E. S. Kenney*, American Electronics

Telemetering Problems for Interplanetary Vehicles. *S. F. Singer*, University of Maryland

Thursday, June 5

Morning—Classified Session

Chairman: R. Colander, Bendix Pacific Division

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

United States National Committee of Commission Internationale de l'Eclairage

THE UNITED STATES, one of 33 countries represented by national committees or local representatives, continues to take an active part in the technical and administrative affairs of the Commission Internationale de l'Eclairage (CIE). The more than 70 members of the United States National Committee (USNC) include representatives of 7 constituent societies—AIEE, American Physical Society, Association of Edison Illuminating Companies, Illuminating Engineering Society, Optical Society of America, Society of Automotive Engineers, Society of Motion Picture and Television Engineers—the National Bureau of Standards, delegates to the last CIE sessions, and members-at-large.

The CIE, which is a sort of International Illuminating Engineering Society, fulfills a fourfold purpose by: (1) providing an international forum for all matters pertaining to the science and art of illumination, (2) promoting the study of such matters, (3) providing for the interchange of lighting information among the countries, and (4) agreeing upon and publishing international recommendations. Technical activities are being carried on by 16 Working Parties and 13 Reporting Secretariats during the quadrenium between the 1955 meeting in Zurich, Switzerland, and the next sessions to be held in Brussels, Belgium, in June 1959.

The more active topics of international interests are assigned to the Working Parties which are made up of from three to eight experts, each representing one of the National Committees, plus correspondents from other member countries (see Table I)

These Working Parties hold such meetings as may be necessary to further their projects. When their work has reached a definite stage, it is expected that reports will be prepared and, after approval, issued as official publications of the CIE.

Other subjects which can be dealt with in progress reports at regular sessions of the CIE are covered by the Reporting Secretariats (see Table II).

As is obvious from the titles of the Working Parties, these groups deal with many fundamental aspects of light, lighting, and vision. The subjects are those in which international agreement is desirable. In general, the conclusions and recommendations of the Working Parties ultimately will serve as bases for improvements in the lighting practices covered by the Reporting Secretariats. In this respect, the CIE functions very much along the lines of the Illuminating Engineering Society and other American technical societies, but it does so on an international basis.

At its annual meeting at State College, Pa., on October 28-29, 1957, more than 60 members and guests of the USNC reviewed the progress being made by the Working Parties and Reporting Secretariats on their assigned tasks. United States participation in the international activities, either by correspondence or attendance at meetings, was well evidenced by the many detailed reports presented by the American Experts and Representatives. While the distance involved makes it difficult for Americans to attend Working Party meetings held in Europe, several were able to participate in such meetings. The reports indicated that all the Working Parties are moving forward toward achieving their objectives.

A special guest, Dr. R. G. Hopkinson of the British Committee of the CIE presented a report on the organization and operation of their National group. Other reports of special interest were presented by Dr. G. A. Fry and Dr. H. R. Blackwell on "Developments in the Field of Visual Performance," and by W. P. Lowell, Jr., on "Behind the Iron Curtain at the International Electrotechnical Commission Meeting."

Plans are now being made for the next international meeting in Brussels. The USNC welcomes the participation of any who desire a wider acquaintance with activities pertaining to lighting throughout the world and who wish to contribute to progress through international co-operation. For those who are interested in information on the 1955 CIE meetings in Zurich, the Proceedings have been published and may be ordered at $15 per set from T. D. Wakefield, Vermilion, Ohio.

The USNC President for 1955-59 is H. H. Magdsick; the Secretray is L. E. Barbrow of the National Bureau of Standards, Washington 25, D. C. The representatives of the AIEE are R. D. Churchill, R. C. Putnam, and D. W. Rowten.

Table I

	Working Party	Chairman	U. S. Expert
W-1.1	Definitions and Vocabulary	H. Koenig (Switzerland)	P. Presbrey
W-1.3.1	Colorimetry	D. B. Judd (U.S.A.)	D. B. Judd
W-1.3.2	Color Rendering	W. Munich (Germany)	D. Nickerson
W-1.3.3	Color of Signal Lights	B. Boorman (Great Britain)	F. C. Breckenridge
W-1.4.2	Visual Performance	H. C. Weston (Great Britain)	G. A. Fry
W-2.1.2	Sources of Measurement of U.V. and I.R.	R. Schulze (Germany)	L. J. Buttolph
W-3.1.1.1	Predetermination of Illumination and Luminance	J. Dourgnon (France)	W. M. Potter
W-3.1.1.2	Causes of Discomfort in Lighting	S. K. Guth (U.S.A.)	S. K. Guth
W-3.1.1.3	Pleasantness in Lighting	L. C. Kalff (Netherlands)	L. S. Harrison
W-3.2	Daylight	R. Cadiergues (France)	J. W. Griffith
W-3.3.1	Streetlighting	J. M. Waldram (Great Britain)	D. W. Rowten
W-3.3.2.1	Aviation Ground Lighting	E. S. Calvert (Great Britain)	C. A. Douglas
W-3.3.3	Airborne Lighting and Signals	T. M. Edwards (U.S.A.)	T. M. Edwards
W-3.3.5	Automobile Headlights and Signals	P. Deveaux (France)	V. J. Roper
W-3.3.7	Traffic Signals	K. Grosskurt (Germany)	E. A. Krawcek
W-4.1.1.	Lighting Education in Schools	P. Spieser (Switzerland)	E. M. Strong

Table II

	Reporting Secretariat	Chairman	U. S. Representative
S-1.2	Measurement of Light	Z. Yamauti (Japan)	G. A. Horton
S-1.4.1.	Photopic and Scotopic Vision	S. G. Yourov (U.S.S.R.)	R. P. Teele
S-2.1.1	Sources of Visible Radiation	G. Siljeholm (Sweden)	E. M. Salter
S-3.1.2	Home Lighting	Ib. Ovesen (Denmark)	M. Fahsbender
S-3.1.3.	School and Office Lighting	M. Paavola (Finland)	C. J. Allen
S-3.1.4	Industrial Lighting	O. Sula (Czechoslovakia)	W. H. Kahler
S-3.1.5	Mine Lighting	V. Boulu (Belgium)	R. S. James
S-3.1.6	Lighting of Public Buildings	R. Grandi (Italy)	J. M. Ketch
S-3.1.8	Light for Selling	S. J. Richards (South Africa)	C. M. Cutler
S-3.1.9.2	Lighting for Photography Cinema, Television Production, and Theatre Stage	W. R. Stevens (Great Britain)	R. S. O'Brien
S-3.3.2.2	Lighting for Transport (other than automobile and air)	R. Eger (Norway)	E. Boghosian
S-3.3.4	Lighting for Indoor and Outdoor Sports	J. O. Freitas (Brazil)	R. T. Dorsey
S-4.2	Lighting Legislation	A. Tchetchik (Israel)	W. C. Wagner

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

AIEE Future Meetings

Great Lakes District Meeting*
Kellogg Center
Michigan State University
East Lansing, Mich.
May 5-7, 1958

AIEE-IRE-ACM Western Joint Computer Conference (Exhibit)*
Ambassador Hotel
Los Angeles, Calif.
May 6-9, 1958

East Central District Meeting*
Prichard Hotel
Huntington, W. Va.
May 13-15, 1958

Vermont Subsection-U of Vermont Power System and Computer Symposium*
University of Vermont
Burlington, Vt.
May 15-16, 1958

Materials Handling Conference*
Penn-Sheraton Hotel
Pittsburgh, Pa.
May 19-20, 1958

Appliance Technical Conference*
Hotel Morrison
Chicago, Ill.
May 26-27, 1958

AIEE-ISA-IAS-ARS National Telemetering Conference (Exhibit)*
Lord Baltimore Hotel
Baltimore, Md.
June 2-4, 1958

Summer General Meeting*
Hotel Statler
Buffalo, N. Y.
June 22-27, 1958

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference (Exhibit)
Statler Hotel
Los Angeles, Calif.
August 5-8, 1958
(Final date for †TP—May 7, ‡CP Syn.—May 22, CPMs—June 2)

AIEE-IRE-NBS Electrical and Radio Standards Conference
University of Colorado and NBS (Dormitory Accommodations)
Boulder, Colo.
August 13-15, 1958
(Final date for †TP—May 15, ‡CP Syn.—May 30, CPMs—June 9)

Pacific General Meeting
Hotel Senator
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 21, ‡CP Syn.—June 3, CPMs—June 13)

AIEE-NEMA National Electrical Insulation Conference
Pick-Carter Hotel
Cleveland, Ohio
September 7-10, 1958
(Final date for †TP—June 9, ‡CP Syn.—June 24, CPMs—July 3)

Petroleum Industry Conference
Baker Hotel
Dallas, Texas
September 15-17, 1958
(Final date for †TP—June 17, ‡CP Syn.—July 2, CPMs—July 11)

Power Industry Computer Application Conference
King Edward Hotel
Toronto, Ont., Canada
September 15-17, 1958
(Final date for †TP—June 17, ‡CP Syn.—July 2, CPMs—July 11)

AIEE-IRE Industrial Electronics Conference
Park Shelton Hotel
Rockham Memorial Auditorium
Detroit, Mich.
September 24-25, 1958
(Final date for †TP—June 26, ‡CP Syn.—July 11, CPMs—July 21)

AIEE-IRE-ASME National Power Conference
Statler Hotel
Boston, Mass.
September 28-October 1, 1958
(Final date for †TP—June 30, ‡CP Syn.—July 15, CPMs—July 25)

AIEE-IRE-EIA-SMPTE National Electronics Conference
Hotel Sherman
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—July 15, ‡CP Syn.—July 30, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel
Hartford, Conn.
October 13-15, 1958
(Final date for †TP—July 15, ‡CP Syn.—July 30, CPMs—Aug. 8)

Fall General Meeting
Penn-Sheraton Hotel
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 12, CPMs—Aug. 22)

Magnetism and Magnetic Materials Conference
Sheraton Hotel
Philadelphia, Pa.
November 17-20, 1958
(Final date for †TP—Aug. 19, ‡CP Syn.—Sept. 3, CPMs—Sept. 12)

AIEE-IRE-ACM Eastern Joint Computor Conference (Exhibit)
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958
(Final date for †TP—Sept. 4, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

AIEE-IRE Global Communication Systems Conference
Colonial Inn-Desert Ranch
St. Petersburg, Fla.
December 3-5, 1958
(Final date for †TP—Sept. 4, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Oct. 29, CPMs—Nov. 7)

Winter General Meeting
Statler Hotel
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Nov. 3, ‡CP Syn.—Nov. 18, CPMs—Nov. 28)

South East-South Central District Meeting
Dinkler Plaza Hotel
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Jan. 8, DPMs —Feb. 2)

East Central District Meeting
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs —Feb. 16)

North Eastern District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs —Feb. 20)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs —March 13)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

**Transactions and conference papers must conform to the requirements in *Authors Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.**

Huntington, W. Va., Will Be Site of AIEE East Central District Meeting

HUNTINGTON, W. VA., is the site of the AIEE East Central District No. 11 Meeting May 13-15, 1958.

Located in the central Ohio Valley, Huntington serves as a trading center for the West Virginia–Ohio–Kentucky tristate area. It is situated in the center of a rapidly expanding industrial section and is a major railway center and river port.

General Session Luncheon

The general session luncheon will be in the Georgian Terrace Room, Frederick Hotel at 11:30 a.m., Tuesday, May 13, with John Reeves of Westinghouse Electric Corporation presiding. The address of welcome will be given by Mayor H. L. Frankel of Huntington, and the keynote address will be presented by J. K. Hodnette, executive vice-president, Westinghouse Electric Corporation, winner of the AIEE Edison Medal for 1957.

Entertainment

On Monday, May 12, at 8 p.m., there will be an Early-Bird Reception at the Frederick Hotel. This is a social event for early arrivals including the ladies. Light refreshments will be served. There will be no charge.

The general session luncheon on Tuesday, May 13, 11:30 a.m., will be open to all members, their wives, and guests. Mayor Frankel will give a brief message of welcome and Mr. Hodnette will speak on "Today's Challenge to Engineering Initiative." Tickets will be $2.75 per person.

An informal cocktail party and dinner will take place Tuesday, May 13, at 6 p.m. The dinner will be served in the ballrom of the Prichard Hotel with H. D. Stillman, Huntington Division manager of the Appalachian Electric Power Company, presiding as toastmaster. Following the dinner, there will be a program of entertainment to which all members, their wives, and guests are welcome. Tickets will be $4 per person.

The Portsmouth (Ohio) Subsection of AIEE will sponsor a luncheon on Wednesday, May 14, at the Prichard Hotel, which is open to all members, their wives, and guests. J. K. Boughton, superintendent of electrical and instrument maintenance, Goodyear Atomic Corporation, Portsmouth, will speak on the "Portsmouth Atomic Story." Tickets will be $2.75 per person.

An Ohio River cruise on the Steamer *Avalon* has been planned for Wednesday at 7:30 p.m. Once a proud Mississippi River Packet, the Steamer *Avalon* has been converted to a modern excursion boat. The only large excursion steamer on the river today, it is a twin-stacked stern-wheeler, with a capacity of 1,370. There are four decks on which to stroll, or sit and relax and view cities along the Ohio River. The Marine Ballroom Deck features an eight-piece orchestra and the Community Players will present an old-fashioned showboat drama, "Curse You Jack Dalton." Door prizes will be given. Dress is strictly informal. Tickets are $2, stag; $3, couple.

The West Virginia Section of AIEE will sponsor a luncheon on Thursday, May 15, at the Prichard Hotel, which is open to all members, their wives, and guests. Dr. R. H. Crist, director of physical processes department, Union Carbide Chemical Corporation, South Charleston, W. Va., will speak on "Engineering Education Today." Tickets will be $2.75.

KYGER CREEK plant is seen from across the Ohio River. The Atomic Energy Commission supply plant, Pike County, Ohio, is operated by OVEC. The total power capacity of Kyger Creek plant is 1 million kw. The second largest steam electric plant ever built by private enterprise, it will be one of the inspection trip visits during the AIEE East Central District Meeting.

Ladies Activities

The Ladies Entertainment Committee has planned an interesting variety of events and trips in addition to the social events already mentioned to which the ladies are invited.

A luncheon and bridge party has been planned at the Huntington Woman's Club on Tuesday at 12:30 p.m. Table and door prizes will be awarded. Tickets are $1.75 per person.

On Wednesday at 9 a.m., a tour will start from the Prichard Hotel to the world-famous Blenko Glass Company, Milton, W. Va., where the ladies will see the artistry and skill involved in making hand-blown glass. The tour will then progress to the Guyan Country Club for a 1 p.m. luncheon and hat show. Tickets are $3 per person.

On Thursday at 1 p.m., a tour will leave the Prichard Hotel to visit the Huntington Art Galleries, located in the scenic hills surrounding Huntington. Tea will be served there from 2 to 4 p.m. Tickets are $1 per person.

A Hospitality Room will be available each day for the ladies at the Prichard Hotel. Refreshments will be served continuously.

Inspection Trips

These trips have been planned to show a cross-section of the industry in the central Ohio Valley. Members are asked to make advance reservations in order that adequate transportation can be provided. Tickets will be available at the registration desk.

Armco Steel Corporation (Tuesday, 1 p.m.). The Ashland, Ky., Works of Armco Steel Corporation has an 80-inch hot strip mill. The first continuous rolling mill in the country with the capacity of 150,000 tons per month, it will roll a 72-inch finished strip down to 20 gauge on the 6-strand, 4-high finishing train. Other facilities are three blast furnaces, eight open hearth furnaces, a 54-inch reversing cold mill, and two continuous coating lines. The plant covers 498 acres and uses as much electricity and 20 times as much water as the entire City of Ashland with a population of approximately 35,000. Tickets are $1.25 per person.

Huntington Publishing Company (Tuesday, 1:45 p.m.). The new installation of the most up-to-date newspaper printing machinery available has a capacity of 50,000 newspapers per hour, 64-pages each. Other points of interest in press operation include a color printing device, new high speed chemical engraving machinery, safety devices, and machinery protective devices, and the interesting operation of mechanical handling of the printed newspapers in the mailing room.

In the Associated Press office visitors will see news received and transmitted from the world-wide services, and wire photos received and transmitted. There will be no charge.

Kaiser Corporation (Wednesday, 8 a.m.). Near Ravenswood, W. Va., the Kaiser Aluminum & Chemical Corporation is constructing an aluminum producing and fabricating facility, which will be one of the largest integrated operations of its

type in the nation when completed. The more than $200 million Ravenswood Works is scheduled to go into production in steps, the initial operation began last year.

The Reduction Division of this plant has an ultimate capacity to produce more than 440 million pounds of primary aluminum per year by an electrolytic process. To provide the electrical energy for the reduction process, Kaiser Aluminum has a 40-year contract with the Ohio Power Company for 450,000 kw. The aluminum oxide requirements for the reduction capacity scheduled for the Ravenswood Works involves the movement of 880 million pounds of aluminum oxide from Louisiana to West Virginia. The aluminum from the Reduction plant will be rolled by giant mills in the Rolling Mill facility. The Rolling Mill will handle up to 10,000-pound ingots of the aluminum which will be rolled into thousands of feet of sheet, foil, and plate products. These ingots will be more than 2 feet thick and can be rolled through a series of mills into aluminum foil to a thickness of 0.00025 of an inch. Sheet aluminum can be rolled to a minimum gauge of 0.006 of an inch. Tickets are $2 per person.

Chesapeake and Ohio (C & O) Railway Shops (Wednesday, 10 a.m.). The Huntington Shops of the C & O railway exists now as one of the most modern installations of its kind in the world. The operation covers approximately 80 acres.

Since the arrival of the first diesel engine in 1948, there has been a gradual changeover from steam to diesel engine maintenance and overhaul, with an accelerated increase in 1954. For the last three years, the C & O has been 100% dieselized.

It is one of the world's largest centers under one roof equipped to handle major repair work on both passenger cars and diesel engines. It is the central location for major mechanical maintenance of C & O rolling stock, other than coal cars. All battery work is performed here, as is all electronic repairs of equipment on rolling stock.

The Testing Laboratory and Chemistry Laboratory, among the most modern on any railroad, have accomplished a great deal in testing and research of various materials used in railroading today.

One of the most unique features of the shops is the conveyor system for overhaul of diesel component parts. This installation has been viewed by personnel from many railroads in the United States, as well as foreign countries, and has received nation-wide publicity. There will be no charge for this trip.

C & O Railway Car Location Information Center (Wednesday, 9:15 a.m.). By the use of IBM and teletype equipment, the Car Location Information Center (CLIC), located in the Chafin Building in Huntington, keeps track of all cars loaded on or moving on the C & O lines. C & O traffic offices in 54 cities throughout the United States and Canada can be notified by the CLIC within two hours after a car has moved on the lines. In addition, the CLIC maintains a 24-hour, 7-day week tracing service for movement information of cars located on or moving over the C & O lines. By combining teletype with IBM equipment, manual key punching of approximately 400,000 IBM cards per month is eliminated. No charge.

GENERAL VIEW of Chesapeake and Ohio Railway's Car Location Information Center at Huntington, W. Va. An inspection trip is planned to the Information Center during the East Central District Meeting of the Institute.

WSAZ-TV Studio (Thursday, 1:15 p.m.). WSAZ, Inc., is the representative of NBC Television and Radio for the central Ohio Valley. The WSAZ facilities include a 5-kw RCA transmitter, a 10-kw RCA transmitter, a 25-kw RCA amplifier, a 1,069-foot antenna tower with service elevator, a large assortment of microwave equipment, a 150-kw diesel standby generator, and other miscellaneous items. The trip will cover the AM and television studios, in which operation of three black-and-white live cameras, one live color camera, a black-and-white film chain, and a 3-V color film chain will be seen. No charge.

Ohio Valley Electric Corporation (OVEC) Kyger Creek Station (Thursday, 10:30 a.m.). Kyger Creek plant, operated by the OVEC, is one of two plants supplying the full electric power requirements of the Atomic Energy Commission's $1.25 billion *U-235* production plant in Pike County, Ohio.

The Kyger Creek plant is at Cheshire, near Gallipolis, Ohio, on an 800-acre tract of land. Kyger Creek has five turbogenerating units of 200,000 kw each, totaling an even 1 million kw. Steam entering the high pressure side of the cross-compound turbogenerators is heated to 1,050 F, and 2,000 pounds per square inch pressure (psi). There are five huge boilers, each fired with pulverized coal, which produce 1⅓ million pounds of steam per hour. The generators which produce power at 15,500 volts, feed directly to transformers that step it up to 330,000 volts for transmission. The coal storage yard stores approximately a million tons of coal. A billion gallons of Ohio River water for condensing steam exhausted from the five units is circulated through the plant and returned to the river each day.

The Kyger Creek plant is the second largest steam-electric plant ever built by private enterprise, larger than any steam-electric plant in operation in June 1945, and the largest power plant in the State of Ohio. Lunch will be served upon arrival at the Kyger Creek Plant. Tickets will be $2.50 per person.

Hotel Reservations

Reservations should be made directly with the hotel of your choice. Rooms with bath are available at the following minimum rates and up:

Hotel	Single	Double	Twin	Suites
Prichard	$5.00	$ 6.50	$ 8.50	$15.00
Frederick	6.50	9.50	11.00	12.00
Gov. Cabell	4.50	7.50	7.50	11.00

The Hotel Prichard is Meeting Headquarters, the Hotel Frederick is located in the center of the city, 2½ blocks from the Hotel Prichard, and the Hotel Governor Cabell is located 2 blocks from the Hotel Prichard.

Registration

The registration desk will open at 4:00 p.m. on Monday, May 12, in the main lobby of meeting headquarters, the Prichard Hotel. This desk will be staffed from 7:45 a.m. to 4:45 p.m. on Tuesday; from 8:00 a.m. to 4:45 p.m. on Wednesday; and from 8:30 a.m. until 12 noon Thursday. Tickets to all events will be available at this desk.

Registration fees for members will be $3 per person and for nonmembers the fee will be $5 per person. Members are encouraged to take advantage of the pre-registration forms which are sent with the meeting notice. For AIEE student members and families of members there will be no fee, but registration will be required.

Committee Chairmen

The members of the East Central District Meeting Committee are: P. C. Kelsey, general chairman; W. R. Wagner, vice-chairman; R. D. Crippen, secretary; A. R. Neal, Jr., boat trip; J. H. Reeves, inspection trip; R. W. Hinshaw, registration; H. C. Willey, technical papers; Carl Latta, hotels; H. P. Hagaman, Jr., students; Jack Steelman, Jr., dinner and luncheons; Mrs. P. C. Kelsey, ladies; E. B. Ellerbe, finance; and M. A. Fotos, Jr., publicity.

Mailed Announcement

A mailed announcement of this meeting will be sent to members in District No. 11. If a copy is desired by members in other Districts, please write to E. C. Day, Assistant Secretary for Technical Papers and Programs, TOD, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

The tentative technical program for the District No. 11 Meeting follows.

Tuesday, May 13

11:30 a.m. General Session Luncheon—Georgian Terrace, Frederick Hotel

Chairman: J. H. Reeves

Address of Welcome: *Hon. H. L. Frankel*, Mayor, City of Huntington

DP* Address: "Today's Challenge to Engineering Initiative," *J. K. Hodnette*, Westinghouse Electric Corporation

2:00 p.m. High Voltage Transmission—Ball Room, Prichard Hotel

Chairman: H. D. Stillman

DP* Arrestor Standards and Development—Their Mutual Effect in Providing Lightning Protection. *G. W. Cooper*, Line Material Company

DP* General Design and Construction of Ohio Valley Electric Company 345-Kv Lines. *R. L. Retallack*, American Gas and Electric Corporation

57-1087 1956 Lighting Field Investigation on the Ohio Valley Electric Company 345-Kv System. *J. G. Anderson*, General Electric Company (GE)

57-1079 Factors Affecting the Lightning Performance of Transmission Lines. *J. H. Hagenguth, J. G. Anderson*, GE

2:00 p.m. Industrial Lighting—Room 208-9, Prichard Hotel

Chairman: G. D. Wilhoit

DP* Fundamental Principles of Industrial Lighting. *H. L. Logan*, Holopane Company, Inc.

DP* Application of Super-High Lamps and High Frequency to Interior Lighting. *W. H. Johnson*, Westinghouse

DP* Techniques of the Application of Mercury Lighting in Industrial Areas. *C. M. Crysler*, GE

DP* Tailoring Fluorescent Sources to Industrial Lighting Needs. *T. C. Sargent*, Sylvania Electric Products, Inc.

2:00 p.m. Cathodic Protection—Ball Room, Governor Cabell Hotel

Chairman: L. S. Van Delinder

DP* Cathodic Protection of Underground Structures. *B. Husock*, Harco Corporation

DP* A Demonstration of Electrochemical Corrosion Reactions. *Col. G. C. Cox*, consulting engineer

Wednesday, May 14

9:30 a.m. Induction Heating—Room 208-9, Prichard Hotel

Chairman: N. A. Baker

DP* Power Sources for Induction Heating. *C. F. Schwan, A. J. Humphrey*, Reliance Electric & Engineering Company

DP* Latest Developments in the Use of Induction Heating. *Dr. H. B. Osborn, Jr.*, Tocco Div. of Ohio Crankshaft Company

DP* Dielectric Heating—Progress in Profits through Losses. *C. R. Looper*, Allis-Chalmers Manufacturing Company

DP* Design of Inductors for Induction Heating. *C. A. Tudbury*, New Rochelle Tool Corporation

9:30 a.m. A-C Distribution in Underground Mines—Ball Room, Prichard Hotel

Chairman: A. C. Muir

DP* Why Consider A-C Mining Underground. *R. C. Berger*, GE

DP58-716 Power Distribution for A-C Mines. *A. C. Lordi*, Westinghouse

DP* Voltage Regulation in A-C Mining. *J. A. Dunn*, Island Creek Coal Company

DP* National and State Electrical Requirements for A-C Mining. *C. Brown*, U. S. Bureau of Mines; *L. H. Harrison*, U. S. Department of Interior

9:30 a.m. Motors—Ball Room, Governor Cabell Hotel

Chairman: J. G. Hawes

DP* Silicone Insulation for Mine Motors. *L. A. Teichthesen*, Dow Corning Corporation

DP* Motor Bearings and Lubrication. *J. E. Youch*, Wagner Electric Corporation

DP* Overload Protection for Electric Motors. *M. R. Brice*, Cutler Hammer, Inc.

2:00 p.m. Application of Motors in Industry—Room 208-9, Prichard Hotel

Chairman: D. A. Ensign

DP* Selection of A-C Motors by Torque Requirements. *C. H. Buchanan*, GE

DP* Selection and Application of Motors in Industry—Chemical, Mining, and Standard Motors. *R. G. Marsh*, Allis-Chalmers

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New York 18, N.Y.

DP* Reversing Electronic Drive for Automatic Feed Applications. *B. B. Finigan*, Reliance Electric & Engineering Company

2:00 p.m. A-C Distribution in Underground Mines—Ball Room, Prichard Hotel

Chairman: D. E. Hamilton

DP* Operation of an A-C Mine. *C. L. Sarf*, Hanna Coal Company, Division Pittsburgh Consolidated Coal Company

DP* Operation of an A-C Mine. *Chester Conrad*, Consolidated Coal Division, Pittsburgh Consolidated Coal Company

DP* Operation of A-C Mines. *W. Painter*, Joy Manufacturing Company

DP58-714 A-C Powered Mining Machines. *R. M. Buckeridge*, Goodman Manufacturing Company

2:00 p.m. Communications—Ball Room, Governor Cabell Hotel

Chairman: A. C. Porter

DP* A PBX Telephone Switchboard for Dispatching Service. *F. W. Treptow*, Bell Telephone Laboratories

DP* New Electronic Techniques in Communication. *P. W. Sinsel*, Chesapeake and Potomac Telephone Company

DP* Some Features of Data Transmission. *R. M. Beer*, Chesapeake and Potomac Telephone Company

2:00 p.m. Telemetering Systems—Mezzanine, Governor Cabell Hotel

Chairman: Ronald Hively

DP* Today's Industrial Telemetering Systems. *Herman Wittenberg*, Control Corporation

DP* A Reverse Application of Storage Type Telemetering. *E. W. Dennis*, Cincinnati Gas & Electric Company

DP* Telemetering Kw-Hr for Use in Tie-Line Load Regulation. *A. L. Hayley, Jr.*, Louisville Gas & Electric Company

Thursday, May 15

9:30 a.m. The Coal Industry—Room 208-9, Prichard Hotel

Chairman: J. C. Norton

DP* Underground Lighting, Today and Tomorrow. *R. E. Havener, D. A. Green*, Mine Safety Appliance Company

DP* Application of Electronics in Coal Mining. *C. H. Reynolds*, Stromberg-Carlson Company

DP* Accelerated Testing of Mining Machine Cable. *W. G. Dahlstrom, A. L. Duna*, American Steel & Wire Division

9:30 a.m. Safety—Ball Room, Governor Cabell Hotel

Chairman: Jack Miller

DP* Some Aspects of Safety in the Use of Electrical Equipment in Coal Mines. *L. H. Harrison*, U. S. Department of Interior

DP* An Evaluation of Safety Performance. *W. H. Brady, Jr.*, E. I. DuPont de Nemours & Co. (Inc.)

58-715 New Data on Resuscitation. *Dr. Peter Safer*, Baltimore City Hospitals

DP* Electrical Shock and Its Effect on the Human Body. *P. E. Hilliard*, Appalachian *Electric Power Company*

9:30 a.m. Distribution of Power—Ball Room, Prichard Hotel

Chairman: S. R. Pritchard

DP* Application of Distribution Overcurrent Protection on AG&E System. *T. J. Meier*, American Gas and Electric Service Corporation

* District Papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

DP* Load Switching's Future—Unlimited. *J. B. Castle*, S&C Electric Company

DP* Bus Plus Supplementary Regulation Offers Economics over Individual Feeder Regulation. *H. E. Lokay*, Westinghouse

2:00 p.m. Power Cables and Connectors—Ball Room, Prichard Hotel

Chairman: H. H. Kincaid

DP* Recent Developments in High-Density Polyethylene Insulating Materials. *B. H. Krevsky*, Bakelite Company

DP* Aluminum vs Copper for Industrial Cable Applications. *J. W St. Andre, H. Esch*, Kaiser Aluminum & Chemical Corporation

DP58-713 Design of Aluminum Connectors. *Morris Brenner*, Penn-Union Electric Corporation

DP58-717 A New ACSR Splicing Method. *E. S. Raila*, Burndy Corporation

2:00 p.m. Computer Applications—Ball Room, Governor Cabell Hotel

Chairman: N. F. Eichenberger

DP* Economic Load Dispatching with Computers. *R. E. Gilbreath*, Westinghouse

DP* Engineers, Computers, and Time. *J. S. Fouch*, International Business Machines Corporation

DP* Application of Digital Computers to Cooling Tower Problems. *R. W. Gausmann*, Indianapolis Power & Light Company

DP* Application of Digital Computers to System Planning Problems. *A. F. Gabrielle, G. W. Stagg*, American Gas & Electric Corporation

2:00 p.m. Voltage Stabilization—Room 208-9, Prichard Hotel

Chairman: Harold Austin

DP* Solving Voltage Problems in Industrial Plants. *B. G. Bailey*, Allis-Chalmers

DP* Power Supply for Automatic Processing—The Voltage Dip Problem. *C. E. Quick*, The Detroit Edison Company

DP* Switching Motors with Capacitors. *G. W. Walsh*, GE

Program Announced for Western Joint Computer Conferencce

THE PROGRAM of the Western Joint Computer Conference, to be held at the Ambassador Hotel in Los Angeles, Calif., May 6-8, 1958, has been released by Conference chairman W. H. Ware of The Rand Corporation. Under the general theme of "Contrasts in Computers," the Conference, sponsored by AIEE, Institute of Radio Engineers (IRE), and the Association for Computing Machinery (ACM), will present 12 sessions during 3 days, divided equally between panel discussions of controversial aspects of computer design and application and technical sessions devoted to individual papers. In addition, an opening panel session under the chairmanship of H. T. Larson of Aeronutronic Systems, Inc., will explore "The Social Problems of Automation," with H. D. Lasswell, professor of law and political science, Yale School of Law; O. A. Knight, president of the Oil, Chemical, and Atomic Workers' International Union; and C. C. Hurd, director of automation research, International Business Machines Corporation (IBM), discussing the broad social problems arising from the introduction of computers and related automatic techniques into our industrial society.

ACM Symposium

On Friday, May 9, following the Western Joint Computer Conference, a symposium on the subject, "Small Automatic Computers and Input/Output Equipment—A Report from the Manufacturers," will be presented by the ACM, under the chairmanship of Paul Armer of The Rand Corporation. The agenda includes a morning and afternoon session of four papers each. The morning will consist of papers contributed by General Electric on character reading, Intelligent Machines Research Corp. on a new common language, Datamatic on the Model *1400* output system, and Stromberg Carlson on their charactron output device. The afternoon session will consist of papers by Telemeter Magnetics on data translators, IBM on the Type *610*, North American Autonetics on the RECOMP II, and Daystrom Systems on a solid-state computer.

Field Trips and Social Activities

Four separate field trips, scheduled for the evenings of May 7 and May 8, will include excursions to System Development Corporation, Bendix Computer, Ramo-Wooldridge, Northrop Aircraft, National Cash Register, ElectroData, and Jet Propulsion Laboratory.

A cocktail party will be held Tuesday evening, May 6, in the Ambassador Ballroom. A luncheon in the hotel's celebrated Cocoanut Grove on Wednesday, May 7, will have M. L. Klein of the Cohu Electronics Co. as guest speaker.

A number of ladies' activities have been scheduled, including extensive trips on Tuesday and Wednesday, May 6 and 7. Special features of these sight-seeing tours will be an "inside look" at 20th Century Fox motion picture studios, a luncheon and fashion show at the Beverly Hills Hotel, Marineland, and an Arthur Murray Cavalcade of Dance at the Plush Horse Restaurant.

Exhibits

Some 40 leading research laboratories, manufacturers, and manufacturers' representatives in the computer field will display their latest products. Representatives of the firms will demonstrate equipment and discuss applicability. All phases of computer technology are represented, including working computer systems, materials, and components, input-output equipment and storage systems. The exhibits are open to the public. Registration is not required.

Conference Committee

The committee of the 1958 Western Joint Computer Conference includes: W. W. Ware, Rand Corporation, chairman; H. T. Larson, Aeronutronic Systems, Inc., vice-chairman; R. E. Utman, Electro-Data Div. of Burroughs Corporation, secretary; K. W. Uncapher, Rand Corporation, finance; Arthur Dowling, Ramo-Wooldridge Corporation, publications; Montgomery Phister, Jr., Ramo-Wooldridge, technical program; W. F. Gunning, Beckman Systems Div., technical program; C. T. Leondes, University of California at Los Angeles (UCLA), technical program; W. A. Farrand, Autonetics Div. of NAA, printing; Marvin Howard, Ramo-Wooldridge, registration; J. J. Seidman, Electronics Div., National Cash Register, hotel arrangements; D. F. Weinberg, Ramo-Wooldridge, exhibits; A. R. McKay, Lockheed Missiles Systems, public relations; P. M. Brown, Aeronutronic Systems, Inc., trips; Nan Glennon, Ramo-Wooldridge, ladies' activities; Billie Keesey, Telemeter Magnetics, Inc., ladies' activities.

The tentative program of Panel Discussions and Technical Sessions follows.

Panel Discussions

Tuesday, May 6

2:00 p.m. Logical Circuitry for Transistor Computers

Chairman: J. H. Felker, Bell Telephone Laboratories

Panelists:

T. R. Finch, Bell Telephone Laboratories, "Resistor-Transistor Logic"

J. B. Angell, Philco Corporation, "Direct-Coupled Transistor Logic"

R. H. Baker, MIT Lincoln Laboratories, "Symmetrical Transistor Logic"

J. L. Walsh, IBM, "Current Mode Logic"

Wednesday, May 7

9:00 a.m. Contrasting Tools and Techniques for Simulation

Chairman: W. Melahn, System Development Corporation

Panelists:

M. Palevsky, Packard Bell, "Incremental Simulation"

J. McCleod, Convair Astronautics, "Electronic Analog Simulation"

W. Varner, Convair, "Combined Analog-Digital Simulation"

H. Gray, University of Pennsylvania, "General Purpose Computer"

H. D. Bennington, System Development Corporation "Dual Machine Simulation"

2:00 p.m. Active Elements for the Machine

Chairman: R. E. Meagher, University of Illinois

Panelists:

I. M. Ross, Bell Telephone Laboratories

S. Kuchinsky, Burroughs Corporation

A. E. Slade, Arthur D. Little Co.

J. A. Rajchman, Radio Corporation of America (RCA)

2:00 p.m. Command Structures

Chairman: J. W. Carr III, University of Michigan

Panelists:

T. O. Ellis, J. C. Shaw, A. Newell, The Rand Corporation; *H. A. Simon*, Carnegie Institute of Technology, "A Command Structure for Complex Information Processing"

J. McCarthy, Dartmouth College and MIT, "OMNITRAN, a Hypothetical Computer for General Symbol Manipulation"

A. W. Holt, W. Turanski, Sperry Rand Corporation, "General Purpose, a Hypothetical Computation and Data File System for Complete Machine Control of its own Programming"

W. Buckholz, IBM, "Present Day Instruction Languages under Engineering Restrictions"

Thursday, May 8

9:00 a.m. Logical Design Methods

Chairman: G. M. Amdahl, Aeronutronic Systems, Inc.

Panelists:

L. Benshy, RCA

R. K. Richards, Consultant

H. Engel, Ramo-Wooldridge Corporation

V. Hess, Litton Industries

2:30 p.m. Very Large Files

Chairman: J. A. Postley, The Rand Corporation

Panelists:

W. Heising, IBM, "RAM Storage Units"

R. Clippinger, Datamatic, "Datamatic System"

E. Cuthill, Bureau of Ships; J. W. Schot, "LARC Tape System"

M. K. Hawes, ElectroData, "DataFile"

Thursday, May 8

9:00 a.m. Digital Computer Circuits

Chairman: S. Ruhman, Packard Bell Computer Corporation

A Direct Read-Out Bistable Circuit and Some Applications of It. *H. Rodriques de Miranda*, Philips Research Lab., Eindhoven, Holland; *I. Rudich*, Amperex Electronic Corporation

Flow Gating. *W. Poppelbaum*, University of Illinois

Minimum Transistor Logic Modules for Airborne Digital Control Applications. *A. Landy, Jr.*, Minneapolis-Honeywell Regulator Company

Design and Application of a Transistor-Magnetic Bi-Logical Computer Element at One Megacycle. *R. Angus, Jr., W. Dunnet, A. Lemack*, Sylvania Electric Products, Inc.

High-Speed Circuit Techniques Utilizing Minority Carrier Storage To Enhance Transient Response. *L. Retzinger, Jr.*, Litton Industries

9:00 a.m. Special Devices II

Chairman: C. T. Leondes, UCLA

The Design, Reading Methods, and System Aspects of the HD File Drum. *H. W. Fuller*, Laboratory for Electronics

Transistorized Modular Power Supplies for Digital Computers. *T. C. Hans*, NJE Corporation

The Dynamics of Toggle Action. *N. L. Kreuder*, ElectroData Div. of Burroughs Corporation

The Shiftrix—Machine Organization for High-Speed Digital Computation. *G. Estrin*, UCLA

A Hybrid Data Processor with Magnetic Tape Input and Direct Pictorial Output. *H. M. Kaiser, S. H. Cameron*, Armour Research Foundation

2:30 p.m. Digital Computer Applications

Chairman: R. Minnick, ElectroData

A Chess Playing Program for the IBM 704. *A. Berstein, M. de V. Roberts, T. Arbuckle, M. Belsky*, IBM

Applications of Digital Computers to Problems in the Study of Vehicular Traffic. *W. Hoffman, R. Pauley*, Wayne State University

The Role of the Digital Computer in Mechanical Translation of Languages. *D. Johnson*, University of Washington

The Application of Large-Scale Electronic Computers to the Assignment of Telephone Facilities. *M. Drandell*, IBM

An Experiment in Mechanical Searching of Research Literature with Ramac. *F. Firth*, IBM

2:30 p.m. Digital Computer Systems II

Chairman: P. Levonian, Ramo-Wooldridge Corporation

Communication between Computers. *R. Stuart-Williams, W. Knowles, I. Wieselman*, Telemeter Magnetics, Inc.

The Universal Data Transcriber. *M. S. Maxwell*, U. S. Naval Proving Ground, Dahlgren, Va.

A Universal Computer-Language Translator. *R. B. Bonney*, Electronic Engineering Co. of California

A New Type of Computer Oriented Toward Spatial Problems. *S. H. Unger*, Bell Telephone Laboratories

The Magnetic Ledger Card Computer. *T. P. Holloran*, National Cash Register Company

Technical Sessions

Tuesday, May 6

2:00 p.m. Special Devices for Computers

MicroSADIC, A High-Speed Data Preparation System with Variable Format Output. *R. Brown*, ElectroData, chairman

A Computer-Integrated, Rapid Access, Magnetic Tape System with Fixed Address. *R. Best, T. Stockebrand*, Lincoln Laboratory

A Device To Facilitate Combined Analog–Digital Operation in Small Computing Installations. *B. Schwartz, et al.*, Battelle Memorial Institute

Direct Access Photomemory—Part I, Prototype Memnine System; Part II, System Considerations. *A. Critchlow, F. Litz*, IBM

Wednesday, May 7

9:00 a.m. Digital Computer Systems I

Chairman: G. Estrin, UCLA

The Flow Diagram Approach to Computer Logical Design Using the NCR 304 as an Illustration. *J. Hudson, W. Edwards, D. Eckdahl*, National Cash Register Company

Cascaded Variable Cycle Control as Applied to the 220 Computer. *E. L. Glaser*, ElectroData Div., Burroughs Corporation

The RCA 501—A Transistor Computer System. *G. E. Poorte, A. S. Kranzley*, RCA, Camden, N.J.

The Remington Rand Univac M-460 General Purpose Digital Computer. *D. Troth, M. Macaulay, J. Thornton*, Sperry Rand Corporation

A Special Purpose Solid-State Computer Using Sequential Access Memory. *W. A. Cornell*, Bell Telephone Laboratories

Buffalo and Niagara Frontier Hosts for Summer General Meeting

BEGINNING June 23 and running through June 27, the 1958 AIEE Summer General Meeting will be held in Buffalo, N. Y. Headquarters will be at the Statler-Hilton Hotel, centrally located in downtown Buffalo. The city of Buffalo, uniquely located astride the busy terminal of 11 major railroads, is a focal point of the great billion dollar New York State Thruway, and the gateway to industrial Canada.

These outstanding environmental facets of Buffalo, "Birthplace of Electrical Power," coupled with the intensive planning of the Standing Committees, headed by D. J. Munhall, promises to make this Summer General Meeting a brilliant technical and social event.

The opening session will be addressed by R. R. Macleod, commercial vice-president of the Niagara Mohawk Power Corporation. In welcoming the membership to this meeting in Buffalo, Mr. Macleod will cover briefly the geography, economics, history, and future of power development in the area. This, of course, dates from the time when the first contract was let in 1890 for the construction of the Edward Dean Adams Station, which provided the first alternating current for system distribution in the United States. This station, still in use, consists of 21 units with an output of 80,000 kw at 25 cycles. As a matter of fact, one of these machines still has the original windings.

Technical Program

At this writing, 33 technical committees in the 6 Divisions have announced plans for 74 technical sessions. In the Power Division, the Transformers and Transmission and Distribution Committees have scheduled three sessions each. There will be two sessions each sponsored by Power Generation, System Engineering, Rotating Machinery, Insulated Conductors, and Switchgear Committees. Protective Devices, Relays, and Substations Committees will have one session each. A joint session will be sponsored by Rotating Machinery and System Engineering.

Committees in the Communication Division have announced two sessions each for Television and Aural Broadcasting and Radio Communication Systems. Other sessions in this Division will include Wire Communication, Communication Theory, and Communication Switching Systems.

In the Industry Division, there will be technical meetings on Chemical Industry, Industrial Control, Industrial Power Systems, and Mining and Metal Industry. Three sessions each by Feedback Control and a joint session by Industrial Power Systems and Mining and Metal Industry is planned.

The Committees in the Science and

Electronics Division are organizing sessions on Nucleonics, Basic Sciences, Solid-State Devices, Magnetic Amplifiers, and Metallic Rectifiers. There will be five sessions on Computing Devices and four on Dielectrics.

Other sessions announced by Committees in the General Applications Division are 2 sessions on Land Transportation and 10 sessions on Air Transportation. In the Instrumentation Division, sessions are being planned on Recording and Controlling Instruments, Special Instruments and Auxiliary Apparatus, Indicating and Integrating Instruments, Aircraft and Flight Test Instruments, and Telemetering.

Social Activities

The Program Committee, headed by E. J. Rahill, has a tentative program that expertly combines the body of the technical program, previously mentioned, with the many events of general interest and social pleasures. The Welcoming Tea on Sunday, June 22, will provide an opportunity for meeting old friends and making new acquaintances. A great deal of thought has been given to making sure that the ladies have as much opportunity as possible to enjoy their visit to Buffalo. One of the outstanding trips planned will be the Niagara Panorama, an all-day tour along the Niagara River. Starting at the Statler-Hilton Hotel, the group will cross the Peace Bridge to Canada and travel along the Canadian side of the Niagara River to view the Oakes Gardens, Rainbow Bridge, and the Carillon Towers, among other things. One of the highlights of this trip will be a ride on the Maid of the Mist, a small boat which actually sails close under the downside of the Falls. This event will provide a trip that will be long remembered.

Inspection Trips

A number of interesting technical trips are planned. As noted, the Edward Dean Adams Station provided the first hydroelectric power station for the distribution of a-c 25-cycle current in the United States. An inspection trip will be made of this interesting installation. The contracts for the first tunnel for this station were let in September of 1890 and included 18.84-foot horizontal tunnels and 21.027-foot vertical tunnels. The generators still consist of sixteen 3,750-kw, 2,200-volt, 852-amperes, delivering 2-phase, 4-conductor, 25-cycle power; and five 3,750-kw, 12,000-volt, 180-ampere units at 3-phase, 25 cycle. An interesting contrast to this first station will be an all-day trip to Canada's Sir Adam Beck Niagara Generating Stations 1 and 2 near Queenston, on the Niagara River, which help make this river one of the greatest sources of hydroelectric power in the world (see photo).

Air Transportation Conference

In conjunction with the Summer General Meeting, the Air Transportation Conference will be held. One of the most important conferences ever held on electrical design aspects of air transportation, it will cover both commercial and military type aircraft power systems, including several sessions on generators and papers covering motors and actuators for control. Tentative programming for the Air Transportation Conference indicates a great deal of interest being shown in new electrochemical power sources for satellites and missiles and in high-altitude performance of silicone solar cells. Technical papers on these latest design advances and specifically projected needs for the future will be presented by top engineers of both the United States and Canada.

Ontario Hydro Photo

SEEN IN THIS AERIAL PHOTOGRAPH are Ontario Hydro's two Sir Adam Beck-Niagara Generating Stations on the Niagara River. These plants, together with the associated pumping–generating station help to make the Niagara one of the greatest sources of hydroelectric power in the world. The 750-acre reservoir and the pumping–generating project and power canal can be seen in the upper center of this picture. The 392,000-kw Sir Adam Beck–Niagara Generating Station No. 1 (lower right), had nine units completed by 1925 and a tenth added five years later. At one time, it was the largest hydroelectric development in existence. Immediately to the left of Sir Adam Beck No. 1 is the completed 900,000-kw, 12-unit phase of the Sir Adam Beck–Niagara Generating Station No. 2 where construction work is now well advanced on the installation of four additional units, two of which have been operating since December 1957. When completed in 1958, the No. 2 station, together with the No. 1 plant and the pumping-generating station, will have an installed capacity of 1,762,000 kw.

Guidance—The Engineer's Responsibility

An Appeal to Members of AIEE from ECPD

ENGINEERS generally are aware of the importance that engineers play in our economy and of the increasing role that they will fill in the future. In spite of fluctuations in the business cycle, the continuation of technological progress in the United States will require a steady and increasing flow of highly qualified engineering graduates into the profession. Our economy and our national defense need engineers and will continue to need them over the years in increasing numbers. Engineers have an obligation to their profession and a continuing responsibility to interest qualified young people in secondary schools in entering the engineering profession.

The Guidance Committee of the Engineers' Council for Professional Development (ECPD) has been engaged in guidance work to interest those secondary school students possessing the necessary aptitudes to embark on engineering careers. Under the sponsorship of the national committee, the country has been divided into eight regions, each with a regional chairman. The regional chairmen have organized state committees to implement the guidance work at the "grass roots" level. It is here that the effective guidance work is accomplished. To date, committees in 48 states and the District of Columbia have been organized. These state guidance committees work directly with the high schools, counseling students to study mathematics and the sciences and urging those who show the necessary aptitudes to consider a career in engineering.

The state guidance committees carry out their objectives through a wide variety of projects and programs, through talks and panel presentations before student groups and assemblies and before teachers, vocational counselors, and parents; through inspection trips and the showing of appropriate technical films; through the promotion of engineering clubs and science fairs; through individual counseling; and through myriad other activities. This is effort by engineers for their profession. This is a professional activity which is not intended to favor particular industries or technical specialties. Rather, the effort is directed toward strengthening the engineering profession so that it may be equal to the task of keeping our technical progress moving forward.

Because not all high school students have the necessary aptitudes, and since it is necessary to interest the qualified to enter engineering colleges, help is needed at the local level to carry on these guidance activities adequately. There is a place and a need for all engineers who are interested to engage in this work. This is written as an appeal to the members of AIEE to volunteer to assist in this effort. Following is a list of regional chairmen with whom AIEE members can communicate:

Region I—E. Donovan, University of New Hampshire, Durham, N. H.
Region II—H. F. Roemmele, dean of students, Cooper Union of Engineering, New York 3, N. Y.
Region III—F. J. Jeffers, Baltimore Gas & Electric Company, Baltimore 3, Md.
Region IV—J. H. Lampe, dean of engineering, North Carolina State College, Raleigh, N. C.
Region V—H. P. Skamser, College of Engineering, Michigan State University, East Lansing, Mich.
Region VI—John Gammell, director of graduate training, Allis-Chalmers Manufacturing Company, Box 510, Milwaukee 1, Wis.
Region VII—Robert Matteson, California Research Corporation, 200 Bush St., San Francisco, Calif.
Region VIII—C. L. Svensen, secretary, State Board of Registration for Professional Engineers, 308 West 15th St., Austin 1, Texas.
For the Regions outside continental United States—R. F. Shaw, vice-president, Foundation Company of Canada, Ltd., 1900 Sherbrook St., W., Montreal, Que., Canada; and M. W. Ball, P.O. Box 3256, Honolulu, T. H.

Symposium on Computer and Electrical Systems in May

The University of Vermont, Burlington, Vt., and the Vermont Subsection of the AIEE will sponsor a Symposium on Computer and Electrical Systems, May 15-16, 1958.

The program for the two-day meeting follows:

Thursday, May 15

1:30 p.m. Afternoon Session—Student Lounge, Waterman Building

G. B. Stibitz, computer consultant, presiding

Welcome Address: E. R. McKee, dean, College of Technology, University of Vermont

The Digital Computer—Your Friend and Servant. *Grace Murray Hopper*, Remington Rand Univac

Some Utility Problems Solved on Large and Small Computers. *Larry Weinstein*, International Business Machines Corporation (IBM)

6:30 p.m. Dinner Session—Faculty Dining Room, Waterman Building

C. W. Hoilman, chairman, Vermont Subsection, AIEE, associate professor of electrical engineering, University of Vermont, presiding

What's Ahead in Computers. *J. F. Blackburn*, IBM, director of engineering research, MIT Computation Center

Friday, May 16

9:00 a.m. Morning Session—Student Lounge, Waterman Building

G. M. McKibben, president, Green Mountain Power Company, presiding

What's New in Distribution. *R. F. Lawrence*, Westinghouse Electric Corporation

Some Fundamentals of Distribution Systems Planning. *F. C. Van Wormer*, General Electric Company

Applications of Computers to Distribution System Problems. *J. L. Rankine*, IBM

1:30 p.m. Afternoon Session—Student Lounge, Waterman Building

N. G. Hodgman, New England Power Company, presiding

Vermont Power Grid. *W. M. Edson*, Central Vermont Public Service Corporation

Design of Vermont 115-Kv Transmission. *A. H. Rogers*, Public Service Company of New Hampshire

Computer Application (subject and speaker to be arranged)

"Meet the Engineer" Sponsored by AIEE Philadelphia Section

On April 1, 1958, the 15-minute weekly radio program "Meet the Engineer," sponsored by the Philadelphia Section of AIEE, celebrated its fifth birthday. During this five-year period, radio time was provided free of charge as a public service by the radio station.

Started in 1953 as an answer to the question "What is an engineer and what does he do?" the program represents an effort by the Philadelphia Section to promote interest in engineering and to acquaint the public with the profession and the role it has in everyday living.

In its broadcasts over the local FM and AM station, WFLN, the program, which is conducted by T. H. MacCauley, chairman of the Section's Radio Commit-

Hoover Medal and John Fritz Medal Presented

AT THE National Convention of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), in New York, N. Y., in February, the Hoover Medal was presented (photo at left) to Scott Turner (right), former director of the U.S. Bureau of Mines, by W. L. Cisler, chairman of the Hoover Medal Board of Award. The award is sponsored jointly by AIEE, AIME, American Society of Civil Engineers (ASCE), and The American Society of Mechanical Engineers (ASME). Photo at right: J. R. Suman (left), of Houston, Texas, receives the certificate of the John Fritz Medal for 1958 from L. K. Silcox, chairman of the John Fritz Medal Board of Award. This award is also sponsored by AIEE, AIME, ASCE, and ASME. Both Mr. Turner and Mr. Suman are past presidents of AIME.

tee, sponsors discussions by leaders in the field of engineering who describe the impact of engineering on the present and future. By making use of tape recordings, it has been possible to present engineering personalities from India, Germany, France, and Great Britain, in addition to prominent men in the United States.

As stated by Mr. MacCauley, the goal of this communication program has been aimed especially at awakening the interest of eligible high school students, parents, and people responsible for vocational guidance. The current and future need for engineers can only be met at the preparatory level. Since engineering education begins at the pre-high school and high school stage when the young student is given a voice in selecting his curriculum of study, an attempt has been made to outline the course of study which would qualify him to undertake an engineering education.

The development of the young engineer after graduation, his role in society, and the importance of his contribution to the progress and security of the country, as well as his own well-being, have been thoroughly discussed. The talks have been tailored to answer the normal questions of "why" and "how" there is such a thing as engineering—"the art and science by which the properties of matter and the sources of power in nature are made useful to men in structures, machines, and manufactured products."

During a recent program, the guest was S. Swayambu, director of the Central Water & Power Commission (Power Wing), Government of India. Mr. Swayambu, who is a 1957 Eisenhower Exchange Fellow, discussed the generation, distribution, and utilization of electric power in India as compared to the United States.

Included among others who have given their views over "Meet the Engineer" are: Philip Reed, chairman of the board, General Electric Company; Dr. L. C. Verman, director of Indian Standards Institution, Bombay, India; Dr. Richard Vieweg, chief of delegation from Germany visiting United States industries; Brigadier General David Sarnoff, chairman of the board, Radio Corporation of America; G. Grosser, manager of Atlantic Region, Westinghouse Electric Corporation; and F. R. Kappel, president of American Telephone & Telegraph Company.

AIEE and ASME Presidents To Speak on "Functional Plan"

W. J. Barrett, president of AIEE and J. N. Landis, president of The American Society of Mechanical Engineers (ASME) will speak on the "Functional Organization of the Engineering Profession" at a luncheon on May 9, 1958, at the Statler Hotel in New York, N. Y.

The occasion is part of the program of the three-day Annual Convention of the New York State Society of Professional Engineers May 8-10, 1958. Visitors are welcome at the luncheon on May 9, when the two Presidents speak.

The discussion will center around the AIEE "Functional Plan," explained in Mr. Barrett's article published in the February 1958 issues of both *Electrical Engineering* and the ASME monthly magazine *Mechanical Engineering*.

Lamme Medal for 1957 Awarded to Dr. H. S. Black

The Lamme Medal for 1957 has been awarded to Dr. H. S. Black (AM '23, F '41), research engineer, Bell Telephone Laboratories, Inc., Murray Hill, N. J.,

> "For his many outstanding contributions to telecommunication and allied electronic arts, especially the invention of the negative feedback amplifier and the successful development and application of the negative feedback amplification principle."

The presentation ceremony will take place on June 23, 1958, during the Summer General Meeting of the Institute in Buffalo, N. Y.

Dr. Black was born in Leominster, Mass., on April 14, 1898. He received the B.S. degree in E.E. from Worcester Polytechnic Institute in 1921 and, in the same year, joined the Western Electric Company's engineering department, which later became Bell Telephone Laboratories. In 1925, Dr. Black was placed in charge of a group which was responsible for developing repeaters, regulators, filters, and other circuits for various carrier telephone systems. It was in this period that the need for a more perfect amplifier became increasingly apparent to him. The invention of the negative feedback amplifier resulted. Dr. Black also has over 60 other inventions to his credit.

H. S. Black

He has been honored by many prizes and awards. In 1934, he received an AIEE

United Engineering Center Site

DEMOLITION PROCEEDINGS at the site of the new United Engineering Center, United Nations Plaza from 47th to 48th Streets, New York, N. Y., are witnessed by AIEE President W. J. Barrett (second from left), president of United Engineering Trustees, Inc.; and W. H. Byrne (left), general chairman of the Greater New York City Commerce Campaign for funds for the new Center. Razing of the present structures was completed in late March and actual groundbreaking for construction is expected later this year. Construction of the new Center, to be financed by anticipated contributions of $5 million from industry and $3 million from membership subscriptions as well as an estimated $2 million from United Engineering Trustees, Inc., assets available for real estate purposes, will take slightly over two years. The new Center is expected to be ready for occupancy in the Fall of 1960.

Best Paper Prize for his paper on "Stabilized Feedback Amplifiers." He was honored in 1940 by the National Association of Manufacturers as a "Modern Pioneer" in ". . . recognition of distinguished achievement in the field of science and invention." He was awarded the John Price Wetherill medal of the Franklin Institute "...for his technical contributions to the efficiency of modern long distance telephony." A Certificate of Appreciation was presented to him in 1946 by the War Department in recognition of assistance during World War II. In 1952, he received the annual award of the Research Corporation for contributions to science. The honorary degree of doctor of engineering was awarded to him by his alma mater, Worcester Polytechnic Institute, in 1955.

Dr. Black is a fellow of the Institute of Radio Engineers, and the American Association for the Advancement of Science; a member of the New York Academy of Sciences, The Franklin Institute, Sigma Xi, Tau Beta Pi; and an honorary member of the Audio Engineering Society. He is the author of a book, "Modulation Theory," published in 1953 by the D. Van Nostrand Co., which is regarded as the definitive writing on this subject.

1958 Nonlinear Magnetics and Magnetic Amplifiers Conference

The AIEE sponsored 1958 Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, convening at the Hotel Statler, Los Angeles, Calif., August 6-8, will present a technical program to be divided into four sessions. This will include technological and theoretical aspects of nonlinear magnetics and magnetic amplifiers, computer applications, special purpose devices and applications, and "new frontiers" in this ever expanding field. Displays by 40 leading manufacturers in the magnetics field will be an additional feature of the program.

For the first time, through a technical conference, the AIEE will offer a scholarship in the name of the author of the best judged technical paper, presented to the university of his choice.

Reports by Subcommittees of Rotating Machinery Committee

The Synchronous Machinery Subcommittee of the AIEE Rotating Machinery Committee urges all users of steam turbine driven generators to obtain copies of the "Guide for Operation and Maintenance of Turbine Generators AIEE No. *67*" which was issued for trial use in July 1957 and is available from Institute Headquarters at no charge. Two new Working Groups have been formed by this Subcommittee. The first is to review the temperature rise standards of large salient pole machines with Class B insulation such as waterwheel generators, and to determine if changes should be suggested to the ASA C-50 Committee to recognize the present industry practice. The second Working Group has been formed to consider development of standards for temperature rise of conductor cooled generators.

The Induction Machinery Subcommittee is engaged in a joint effort with the Relay Committee to collect information on motor characteristics which can be used to establish standards for motor protection. A planned program is now in progress to test motors to obtain this information. A Stray Load Loss Working Group established at the Summer General Meeting in 1957 is actively obtaining test data. This Working Group is to secure and assemble data on stray load loss tests, study and analyze the tests, and recommend suitable tests which might supplement or replace the Reverse Rotating Test as given in Test Code AIEE No. *500*, ASAC-50.20-1954, if this test is found to be inadequate. The test program is about half finished.

The Insulation Subcommittee is investigating proposed changes in the A-C Dielectric Acceptance Tests on machines rated 20 kv and above. One proposal has been made, but this item is in the preliminary discussion stage. Progress was reported on the revision of the "Guide for Insulation Resistance Measurements AIEE No. *43*." The revisions of the text are complete but the Working Group is hoping to simplify the formulas. A Working Group to investigate the Evaluation of Hermetic Motor Insulation Systems was formed at the AIEE Fall General

Annual Meeting

The Annual Meeting of the American Institute of Electrical Engineers will be held in Buffalo, N. Y., at 2:00 p. m., Monday, June 23, 1958, during the Summer General Meeting.

At this meeting, the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to Harold S. Black (AM '23, M '33, F '41).

Such other business, if any, as may properly come before the Annual Meeting may be considered.

Signed
N. S. HIBSHMAN,
Secretary

AIEE Lehigh Valley Section

AT A RECENT MEETING (above, *left*) of the AIEE Lehigh Valley Section in Allentown, Pa., the main speaker was T. H. MacCauley, who spoke on "The Engineer's Place in the Community." Mr. MacCauley (*left*) is shown with R. B. Roush, Allentown Division manager, and "friend," Ben Franklin. Above, *right*: W. F. Mackenzie, chairman, Prize Paper Committee, AIEE Lehigh Valley Section (*right*), presents certificates to 1957 prize winners (*left to right*) C. A. MacArthur, C. W. Watchorn and W. R. Smith, third, second, and first prize paper authors, respectively. The presentations were made at the recent Allentown Division meeting.

Meeting with P. L. Alger as chairman. This group reported that it had formed two subgroups, one on materials and the second on insulation systems.

The D-C Machinery Subcommittee is investigating load losses in d-c machines. A literature survey is now under way and further action will be determined after this survey is completed. The Subcommittee reports that the "Test Code for Direct-Current Machines AIEE No. *501*" was issued July 31, 1957, and a "Proposed Guide for Determination of Short Circuit Characteristics of Direct-Current Machinery AIEE No. *66*" was issued for trial use in July 1957.

50-Year Member Honored at Michigan Section Meeting

At a meeting of the Michigan Section of AIEE on February 11, 1958, Michigan State Highway Commissioner J. C. Mackie spoke to 85 members and guests of the Section assembled at the Jackson Country Club.

Among the topics discussed by Mr. Mackie were the need for toll roads in Michigan, traffic safety, and the current five-year highway building plan which calls for 900 miles of expressways connecting all major Michigan cities of more than 50,000 population as well as construction or reconstruction of 2,900 miles of other roads in the State. Projects included in the plan are: an expressway from the Ohio border across the Mackinac bridge and the upper peninsula to Canada; expressways from Detroit to New Buffalo and Chicago, and from Detroit to Muskegon; paving of the remaining 800 miles of gravel trunkline roads in the State, and $400 million or more for urban area projects, including $322 million for a stepped up Detroit metropolitan expressway program.

At the same meeting, J. C. Langdell (AM '07, F '47, Member for Life), a retired Commonwealth Associates engineer, was presented a certificate to commemorate 50 years membership in the AIEE. Adolph Rauth of Consumers Power Company described Mr. Langdell's long career as an electrical engineer, and Howard Hess of Detroit, chairman of the Michigan Section, presented the letter of commendation.

Recent Activities of the AIEE Philadelphia Section

C. S. Schifreen, cable and insulation research engineer, Philadelphia Electric Company, received his Fellow Diploma and also delivered a talk on "Underground Power Transmission" at the March Philadelphia Section meeting. Mr. Schifreen discussed impressions obtained during his recent trip to Europe as a member of the joint Association of Edison Illuminating Companies–Edison Electric Institute Committee on Extra High Voltage Research.

Mr. Schifreen said that although high-voltage cable research was further advanced in Europe than in the United States, it was proceeding along somewhat different lines. He felt that presently d-c transmission was more advantageous in Europe where entirely different systems could now be tied together rather than in the United States where there already are many interconnected systems. Mr. Schifreen stressed that research and field trials must start now for the items that will be needed 15 or 20 years hence. As an example, he indicated that although the Philadelphia Electric Company installed its first pipe-type cable some 20 years ago, only recently has this become a commonly accepted practice.

The December Section meeting featured a talk by Dr. J. K. Davis, manager of Electronic Products Development Division, Corning Glass Works, on "Pyroceram and Other New Engineering Developments in Glass" (*Electrical Engineering*, August 1957, p. 755). His talk, together with a fascinating movie on glass development and production, was a real eye-opener for most of those in the audience. Dr. Davis described the many new glass products including glass capacitors

AT A RECENT MEETING of the Michigan Section of AIEE were: (*back row, left to right*) J. W. Eakins, Section secretary-treasurer; B. H. Schneider, Section vice-chairman; H. M. Hess, Section chairman; R. E. Albrecht, program chairman; (*front row, left to right*) J. C. Langdell, special guest honored for his 50 years' membership in AIEE; J. C. Mackie, main speaker, Michigan State highway commissioner; and A. Yarmy, administrative assistant to Michigan State highway commissioner.

C. S. SCHIFREEN, Philadelphia Electric Company, received his Fellow Diploma at the March meeting of the AIEE Philadelphia Section. Shown (*left to right*) are: L. R. Gaty, Philadelphia Electric Company; Mr. Schifreen; A. H. Kidder, Philadelphia Electric Company; and B. H. Zacharia, United Engineers & Constructors, Section chairman.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until May 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before May 27.

58-144 Treatment of Hydro Capability Duration Curves in Probability Calculations. *K. L. Hicks*

58-167 Performance Computer for Steam-Electric Generating Units—Part I. *A. J. Hornfeck, T. S. Imsland*

58-168 Evaluation of Combustion Control-Load Control Tie-In Equipment at Niles Station of Ohio Edison Company. *R. H. Travers, D. B. Zelenka, H. A. List, C. Nichols*

58-207 Operating Experience with West Penn Power's Economic Dispatch Computer. *W. R. Hamilton, W. H. Osterle*

58-211 Internal Oxidation Mechanism for Nontracking Organic Insulations. *R. S. Norman, A. A. Kessel*

Also, the following technical papers which were not so listed on the AIEE Winter General Meeting and the Middle Eastern District Meeting programs, respectively:

58-1 End Component of Armature Leakage Reactance of Round-Rotor Generators. *R. T. Smith*

58-576 Electrical Features of Eddystone Station. *E. B. Shew, F. W. Myers*

Reprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Boston Section Meeting

Fay Foto Services, Inc.

AT A MEETING of the AIEE Boston Section on February 11, 1958, were: (left to right) J. C. Hitt, Section vice-chairman; P. L. Bellaschi, consulting engineer, speaker for the evening; and W. F. Burt, secretary-treasurer of the Section. In his talk entitled "Power Transmission at the Extra-High Voltages—Developments and Trends," Mr. Bellaschi discussed developments in the extra-high voltages in the United States, Canada, and abroad with special attention to the selection of voltage, choice of conductor (single and bundle), insulation levels of line and terminals, the application of terminal equipment (transformers, lightning arresters, etc.), protection, the right-of-way problem, and other factors which determine the cost of transmission and the operation of the system at the higher voltages.

and resistors, photosensitive glasses, and pyroceram which currently is being used in missile nose cones.

Dr. P. W. Schafer, executive director, Television Division, Walter Reed Medical Center, addressed the January main Section meeting. Dr. Schafer described the facilities in use at Walter Reed and the present and proposed programming plans. He stated that color broadcasts were now being transmitted to other Government medical facilities in the Washington, D. C., area and indicated that plans were under way for a series of broadcasts to medical installations located in the country's metropolitan areas. Dr. Schafer further stated that color kinerecordings would be made available to personnel in medical installations located in remote areas of the world so that they could keep pace with advances in medicine and surgery.

Conference on Electronic Standards and Measurements

The AIEE Electronic and High-Frequency Instruments Committee, under the chairmanship of Ferdinand Hamburger, Jr., is serving as cosponsor of a conference of national scope to be held in Boulder, Colo., August 13-15, 1958. Other cosponsors will include the Professional Group on Instrumentation of the Institute of Radio Engineers (IRE), and the Radio Standards Laboratory of the National Bureau of Standards (NBS).

The technical program of the Conference on Electronic Standards and Measurements is being organized to parallel the work of NBS in the development, maintenance, and dissemination of basic standards for electricity, radio, and electronics. Papers and discussions at a national level will offer a broad and comprehensive view of standards and measurement techniques in the ever-growing electronics field.

A series of somewhat similar conferences on measurements and standards was held in Washington, D. C., on alternate years from 1949 to 1955. The 1958 Conference in Boulder will cover topics ranging from direct current to microwave standards. Papers also are being directed toward the more fundamental aspects of standards and measurements. Six technical sessions are being prepared under the guidance of I. G. Easton, chairman of the Technical Program Committee. Mr. Easton, the AIEE representative on the General Arrangements Committee, is also serving on the Advisory Committee for the Conference.

Technical sessions of the Conference will cover the following subjects:

(1) The relationship of standards to physical constants: methods of using physical constants to express primary standards, the determination of important physical constants by exploiting existing standards.

(2) Frequency and time interval standards.

(3) Direct-current and low-frequency standards.

(4) Radio-frequency standards: measurement of voltage, current, power, imped-

ance, attenuation, phase shift, field strength.

(5) Microwave standards: measurement of power, impedance, attenuation, noise.

(6) The organization and operation of standards laboratories.

As an added feature of the Conference, NBS will dedicate the new Electronic Calibration Center located at its Boulder Laboratories. Inspection of this and other new facilities of the Laboratories should be of considerable interest to the Conference participants. For this and other events, several speakers of national prominence are being invited to take part in the Conference. Various social events are also planned.

The proximity of Boulder to Denver, Rocky Mountain National Park, and to an extensive vacation area makes the location and time of the Conference particularly attractive to those who wish to combine their attendance with a vacation period.

The technical sessions will be held at the NBS Boulder Laboratories; ample housing accommodations on the nearby campus of the University of Colorado have been reserved.

An initial announcement of the Conference was distributed by mail early in February. A second announcement will be mailed about June 30. If you wish to receive a copy, write to: J. F. Brockman, National Bureau of Standards, Boulder Laboratories, Boulder, Colo.

Texas Engineers Discuss AIEE Proposal

At a meeting of the San Jacinto Chapter of the Texas Society of Professional Engineers held March 10, 1958, the AIEE proposal for dividing professional activities and responsibilities among the major engineering organizations was discussed.

Details of the plan were presented to over 100 local chapter members attending the meeting by N. E. Hull, vice-president of Hughes Gun Co., and vice-presidential nominee of the National Society of Professional Engineers.

Dr. Kaplan Speaks at Los Angeles Section Meeting

The Aircraft Division of the Los Angeles Section of AIEE sponsored a dinner meeting in March at which Dr. Joseph Kaplan spoke on the International Geophysical Year (IGY). Dr. Kaplan, who is professor of physics at University of California at Los Angeles, has an international reputation as a scientist and has gained fame as the chairman of the United States IGY Committee.

Approximately 200 members of the Los Angeles Section attended this meeting at which Dr. Kaplan presented many interesting facts gathered by intimate association with the project over the last five years. During his introduction, it was pointed out that two years ago he stated that the USSR would launch a satellite approximately in October 1957 and that the United States would launch their first satellite in January 1958. Dr. Kaplan was one of the many surprised persons when confronted with these facts and went on to present many interesting statements concerning his favorite scientific work.

Dr. Kaplan pointed out that the first geophysical year was 1882 and that, at that time, it was realized that all nations of the world should work together for scientific advancement. From this humble start, it is of interest that 66 nations have co-operated in scientific study during the 1957-58 geophysical year.

A prime research interest of Dr. Kaplan's is the specter of the aurora borealis which was discovered in 1882 to appear in association with the magnetic axis of the earth. This year it was realized this phenomena could be a controlling factor in outer space study and travel. It is now

Fellow Diploma Presented

R. D. BARRETT (*left*), chairman of the Memphis (Tenn.) Section of the AIEE, presented a Fellow diploma to C. L. Osenbaugh (*right*) of the Memphis Light, Gas & Water Division, at the March 18, 1958, Section Meeting.

AT A DINNER MEETING sponsored by the Aircraft Division of the Los Angeles Section of AIEE were: (*left to right*) M. J. Cronin, program chairman; Dr. Joseph Kaplan, principal speaker; H. A. Lott, chairman of the Section; E. D. Barcus, vice-chairman of the Section; and (*seated*) C. N. Parker, chairman of the Riverside–San Bernardino Subsection.

generally believed that the sun is the key to the use and control of outer space.

Dr. Kaplan stated that a very sophisticated program is being planned for the future based on the research studies of the past 75 years. This program will include a greatly expanded study of cosmic rays, which was a major research problem this year. It is also believed that research will be carried on in fields unknown today.

Many questions were answered after Dr. Kaplan concluded his talk and it was stated that recovery of satellites from a height of 3,000 to 5,000 miles is possible, if needed. It was stated that in a great many cases such as photographing of cosmic rays, recovery is desirable. It was further pointed out that where some calculations were in error, many were very accurate. The calculation of temperature ranges within satellites was found to be extremely accurate.

The IGY Committee, of which Dr. Kaplan is chairman, is very pleased with the United States progress in satellites and research studies of the 1957-58 geophysical year.

AIEE FELLOWS ELECTED

Board of Directors Meeting, February 7, 1958

Howard Allan Chinn (M '45), chief engineer, CBS Television, New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the development of measuring and monitoring equipment in the audio and video broadcasting field." Mr. Chinn was born in New York, N. Y., on January 5, 1906. He joined CBS in 1932 after receiving S.B. and S.M. degrees from Massachusetts Institute of Technology where he was a research associate for five years after graduation. At CBS, he held various engineering positions leading to the present one, chief engineer, and has been engaged in administration, and in design, development, and construction of audio, video, and associated facilities for radio and television studios, for sound and video recording plants, and for motion picture and animated film studios. From 1942 to 1946, he was employed on a consulting basis only to permit participation in war work. From 1942 to 1943, he was technical co-ordinator for the Radio Research Laboratory at Harvard University (under contract with National Defense Research Council) and from 1943 to 1946, he was consultant with the Office of Scientific Research and Development, Division 15 of the National Defense Research Council. For his work with the Office of Scientific Research and Development, he received a Presidential Certificate of Merit, the second highest award available to civilians. In 1950, he received the John H. Potts Memorial Award for outstanding achievement in the field of audio engineering. Mr. Chinn is a fellow of the Audio Engineering Society, the Institute of Radio Engineers, the Society of Motion Picture and Television Engineers, and the Acoustical Society of America. He is a registered professional engineer in the States of New York and Connecticut. He is the author of "Television Engineering," one of the volumes in the McGraw-Hill television series, and is the author of more than 60 papers which have appeared in contemporary technical journals, proceedings, and magazines.

Joseph Bolen Epperson (M '50), vice-president in charge of engineering for Scripps-Howard Radio, Inc., Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for achievements in the broadcasting field." Mr. Epperson was born in Charleston, Tenn., May 8, 1910. He attended the University of Tennessee from 1927 to 1930 and is a graduate of the Capitol Radio Engineering Institute, Washington, D. C. In 1931 he became chief engineer of Radio Station WNOX, Knoxville, and in 1938 he was made chief engineer for Scripps-Howard Radio, Inc. During World War II, Mr. Epperson was a member of Dr. W. L. Everitt's Operational Research Group at the Pentagon in Washington. Among other things, he was co-author of: "Radar Electronic Fundamentals" and "Radar System Engineering." He has written several technical articles for *Electronics* and other engineering publications. From 1944-46, he was with the Engineering Products Division of the Radio Corporation of America at Camden, N. J. In 1946, Mr. Epperson returned to Scripps-Howard Radio, Inc., making his headquarters in Cleveland, Ohio. He supervised the building of Ohio's first licensed television station—WEWS—which was placed in operation in 1947. WCPO-TV and WCPO-FM, Cincinnati, Ohio, began operation in 1949. He was made engineering vice-president for Scripps-Howard in 1956. Mr. Epperson is currently chairman of the National Association of Broadcasters (NAB) Engineering Conference Committee, chairman of the Technical Committee for Maximum Service Telecasters (MST), member of the Board for MST, and member of the Board for the Television Allocations Study Organization (TASO). He is a registered professional engineer in the District of Columbia and is a member of the Tennessee Alpha Chapter of Tau Beta Pi. He is a fellow of the Institute of Radio Engineers, active member of the Society of Motion Picture and Television Engineers, member of Broadcast Pioneers, and associate member of the Association of Federal Communications Consulting Engineers. Mr. Epperson has served on the AIEE Television and Aural Broadcasting Systems Committee since 1952, and was chairman, 1954-56. He was a member of the Communication Division Committee, 1954-56. In 1954-55, he served as liaison member to the AIEE Standards Committee. He served on the local AIEE Cleveland Section Membership Committee, Hospitality Committee, and is currently chairman of the Professional Subcommittee of the Membership Committee.

Arthur McCredie Harrison (M '46), manager, large rotating apparatus department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in the field of large rotating electrical machinery." Mr. Harrison was born in Pittsburgh, Pa., on July 7, 1905. He received the B.S. degree in E.E. from Carnegie Institute of Technology in 1926. After graduation he joined the Westinghouse Graduate Student Course and later in 1926 was employed in the d-c engineering department of the Transportation and Generator Division in

H. A. Chinn

Madison Geddes

J. B. Epperson

A. M. Harrison

C. L. Osenbaugh

C. S. Schifreen

M. C. Westrate

East Pittsburgh, as a design engineer. In this capacity he designed large d-c motors and generators of all types for industrial uses and for marine propulsion, including generators and propulsion motors for fleet type submarines. In 1940, he acted as a consultant to the U. S. Navy on degaussing and minesweeping problems. In 1945, he became section manager, and in 1950 was made manager of d-c engineering. In this position, he was responsible for design and development of all large d-c motors and generators built at East Pittsburgh. In 1952, Mr. Harrison became manager of the transportation engineering department. In 1954, he was made manager of engineering of the Transportation and Generator Division of East Pittsburgh. In this capacity he directed the design and development of all large rotating apparatus, including turbine generators, waterwheel generators and synchronous condensers, large a-c motors and d-c motors of all types. He held this position until 1957 when he became manager of the large rotating apparatus department. In his present status, he is responsible for engineering, sales, and manufacturing of all large rotating machinery. Mr. Harrison is a registered professional engineer in the State of Pennsylvania. He is a member of The American Society of Mechanical Engineers and American Standard Association (served as chairman of subcommittee on exciters, 1956-57). He is also a member of Eta Kappa Nu and Sigma Tau. Mr. Harrison is the author and co-author of several AIEE technical papers. In 1956, he coauthored a paper on "Technical Advances in Steam Turbine Generators" which was presented at the Fifth World Power Conference in Vienna, Austria. He has served on the following AIEE Committees: Student Branches (1947-48), Rotating Machinery (1951-53), and Land Transportation (1953-55).

Chester Lamott Osenbaugh (AM '37, M '44), director of the Electric Division, Memphis Light, Gas & Water Division, City of Memphis, Tenn., has been transferred to the grade of Fellow in the AIEE ". . . for design and administrative achievements in directing the engineering, construction, and operation of an electric utility system." Mr. Osenbaugh was born in Ottawa, Ohio, April 8, 1903. He received the B.S. degree in E.E. in 1927 and the E.E. degree in 1931 from Purdue University. From 1927 to 1932, he was with the Ohio Power Company, Tiffin and Canton, Ohio, in work involving substation construction, switchboard wiring, meter tests and installation, substation engineering, and distribution engineering. From 1932 to 1936, he was employed for short periods by the Ohio Edison Company, Timken Roller Bearing Company, and others. Since 1936, he has been with the Memphis Light, Gas & Water Division where he has held positions as overhead distribution engineer, chief overhead design engineer, and chief electric distribution engineer. In charge of the engineering department, his work consisted of design of distribution systems, including the design of standards, writing of specifications, estimating, getting out contracts, and working with contractors during construction. In June 1955, he was named assistant director of the Electric Division and since November 1955, he has been director. In this position, he is responsible for the co-ordination of work between the various departments and the over-all supervision of the Electric Division which includes overhead and underground distribution, transmission, and substation design, construction, operation, and maintenance. Since 1940, the peak hour demand on the system has increased from 71 to 442 megawatts. Mr. Osenbaugh is a registered professional engineer in the State of Tennessee and is a member of the Engineers Club of Memphis. He served as chairman of the Memphis Section of the Institute, 1941-42.

Clement Solomon Schifreen (AM '26, M '43), cable and insulation research engineer, Philadelphia Electric Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions toward extended life and load ratings of underground power cables." Mr. Schifreen was born in Catasauqua, Pa., on September 23, 1901. He graduated with first honor from Lehigh University in 1923 with the E.E. degree and received the degree of LL.B. from Temple University in 1932. He is a member of Phi Beta Kappa, Tau Beta Pi, Pennsylvania Society of Professional Engineers, Philadelphia Engineers Club, International Conference on Large Electric High-Tension Systems. (CIGRE), Franklin Institute, Institute of Radio Engineers and other technical groups. Mr. Schifreen has been employed by Philadelphia Electric Company continuously since 1923, except during 1937-38 when he practiced law in Philadelphia. From 1923 to 1940, he worked in the company's Electrical Construction, Drafting, and Electrical Engineering Divisions on station and substation control and auxiliary projects. From 1940 to 1956, he supervised the engineering development of the company's new high-voltage, high-capacity cable systems. During this period, he developed his widely accepted method for evaluation of cable sheath life which lead to the adoption of triplex cable construction for applicable cables as standard for his and other companies. He directed his company's researches leading to identifying a type of sand as an inexpensive and effective heat dissipating material for underground cable environment. In his present assignment, since 1956, he has been working on means to ameliorate or bypass the thermal limitations inherent in present bulk power cable transmission and is directing the company's evaluation of bulk-power high voltage d-c transmission. Mr. Schifreen is the author of numerous technical papers and was one of the editors of the revised Edison Electric Institute (EEI) Underground Systems Reference Book. He served as treasurer (1945-49) and on the Board of Managers (1942-45) and on many committees of the Philadelphia Section of the Institute. He also served on the AIEE Research Committee (1947-52) and is a member of the Insulated Conductors Committee (1954-58). He was recently appointed vice-chairman of the Association of Edison Illuminating Companies (AEIC) Cable Engineering Section, on which he is also a member of the Steering Committee and its European Visiting Committee on Extra High Voltage Cables.

Millard C. Westrate (AM '37, M '43), staff consulting engineer, Commonwealth Associates, Inc., Jackson, Mich., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to economic operations of power systems and to high frequency radio communication." Mr. Westrate was born in Allegan, Mich., August 16, 1908. He received his B.S. degree in E.E. from the University of Michigan in 1930. From that time until 1943, he worked for Consumers Power Company and The Commonwealth & Southern Corporation, first on the 30- to 60-cycle frequency change, then as a power sales engineer, and then as an electrical engineer in the technical section working on various technical assignments involved

with electric system planning and development. Most of 1943 and 1944 was spent on the war effort as chief engineer for Communication Equipment and Engineering Company, working on many communication problems and particularly the production control of airborne antennae for the ILS system used on all of the United States bombing planes. He was responsible for the design of test equipment which was a major factor in making it possible for the company to meet production schedules at a very critical time. From 1944 to 1951, he served as superintendent for the City of Holland (Mich.) Board of Public Works, a position which included responsibility for the generation and distribution of electricity for this city and the surrounding area. During this time, he also organized the Holland Broadcasting Company and, as president and chief engineer, designed, and built Radio Station WHTC. In 1951, he returned to Commonwealth Associates which had succeeded The Commonwealth & Southern Corporation engineering department, serving first in system planning work and as head of this department, then as assistant chief electrical engineer, and now as staff consulting engineer. He has been responsible for the long-range planning of several electric systems, including some of the largest ones, and for the development of economic dispatch and dispatch computers. Mr. Westrate is a member of the Institute of Radio Engineers and the National Society of Professional Engineers. He has served on the System Engineering Committee (1952-54, 1955-58), and is chairman of the Technical Program Committee for the 1958 Great Lakes District Meeting of the Institute to be held May 5-7.

AIEE PERSONALITIES

J. E. Housley (AM '19, F '43, Member for Life), veteran district power manager of Aluminum Company of America's Tennessee operations at Alcoa, retired February 1, 1958, after more than 42 years of service. Mr. Housley, who served as president of AIEE (1946-47) is recognized as an international authority in the field of hydroelectric development. **Mead Warren, Jr.,** (AM '42, M '49), assistant district power manager, succeeds Mr. Housley. Past president Housley served on many AIEE Committees including: Standards (1944-46); Technical Program (1944-46); Membership (1940-41); Industrial Power Applications (1942-43); Executive (1946-48, chairman 1946-47); John Fritz Medal Board of Award (1946-52); Executive Committee, U. S. National Committee, World Power Conference (1946-47); Industry Co-ordinating (1947-48). He was vice-president of AIEE District No. 4 (1941-43). Mr. Warren has served on the following Institute Committees: Communication (1945-46), Power System Communications (1947-58), and Power Generation (1954-58).

J. W. Horton (AM '20, F '28, Member for Life), chief research consultant, U. S. Navy Underwater Sound Laboratory, Fort Trumbull, New London, Conn., recently received the Navy Distinguished Civilian Service Award—the highest recognition accorded by the Navy Department for civilian service to the Navy. In the citation, Dr. Horton was commended for his " . . . long and brilliant career intimately associated with the Navy's program in underwater acoustics" and for the publication last year of his book "Fundamentals of Sonar" as "a scientific achievement of great importance and significance." Dr. Horton is serving on the AIEE Board of Examiners (1950-58).

K. G. Kempf (AM '43), manager of the Pacific Coast Division of The Thomas & Betts Company, Elizabeth, N. J., has been appointed vice-president in charge of the Sta-Kon Division.

R. E. Pierce (AM '21, F '47), consulting electrical engineer, Ebasco Services, Inc., has been appointed chief consulting engineer to succeed **H. L. Melvin** (AM '13, F '31, Member for Life) who continues with the company as a general engineering consultant. **S. B. Smith** (AM '36, M '42), was named consulting electrical engineer. Mr. Pierce has served on the AIEE Protective Devices Committee (1943-47) and Transmission and Distribution Committee (1949-53). Mr. Melvin is a member of the Lamme Medal Committee (1957-60). Mr. Smith is serving on the Transmission and Distribution Committee (1957-58).

R. B. Zane (AM '34, M '40), manager of railroad sales in the Chicago (Ill.) district of The Okonite Company, has been appointed to the newly established position of manager, utilities and industrials, at the Chicago office.

J. W. Kearney (AM '44, M '50), head of the Special Devices Section, Airborne Instruments Laboratory (AIL), Mineola, N. Y., has been promoted to the position of head of AIL's newly formed reconnaissance department. Mr. Kearney has served on the following Institute Committees: Radio Communication Systems (1950-52), Electronic and High-Frequency Instruments (1956-58), and Award of Prizes (1956-57).

W. R. Ellis (AM '40) and **W. H. Hamilton** (M '55) are two of the six engineers and scientists of the Westinghouse Bettis Atomic Power Division who have been awarded the Westinghouse Order of Merit for their outstanding work on atomic submarine projects and the Shippingport atomic power station. Mr. Ellis is manager of the power plant section, Shippingport project, and Mr. Hamilton is manager of the S3W and S4W projects.

Waldo Porter (AM '44), northwest power manager for Aluminum Company of America, has been appointed production assistant in the company's Smelting Division. Succeeding Mr. Porter was **W. E. Lawton** (AM '48, M '54), chief electrical engineer at Alcoa's Vancouver (Wash.) works. Mr. Porter has served on the following Institute Committees: Chemical, Electrochemical, and Electrothermal Applications (1946-58), Industrial Power Rectifiers (1949-58), and Industrial Power Systems (1950-53). Mr. Lawton served on the Industrial Control Committee (1951-54).

L. N. McClellan (AM '14, F '38, Member for Life), assistant commissioner and chief engineer of the Bureau of Reclamation in Denver, Colo., retired from public service on February 28, 1958, after a distinguished career of more than 45 years in the development of water and land resources. Mr. McClellan has served on the following Institute Committees: Power Transmission and Distribution (1933-36), Automatic Stations (1937-39), Applications to Mining Work (1937-38), and Members-for-Life Fund (1951-53).

A. W. Kramer (AM '19, M '34, Member for Life), editor of *Power Engineering* magazine, has been named editor of *Atomics* and technical assistant to the president of Technical Publishing Company, Barrington, Ill., publishers of *Power Engineering*, *Plant Engineering*, and *Atomics*.

R. J. Kuhn (M '31), corrosion engineer for New Orleans Public Service Inc., New Orleans, La., received the Frank Newman Speller Award of the National Association of Corrosion Engineers. Mr. Kuhn served on the AIEE Chemical, Electrochemical, and Electrothermal Applications Committee (1947-52).

D. H. Levy (AM '23, F '47), a director of Magnolia Pipe Line Company, Dallas, Texas, and general superintendent of the company's communications and electrical department, retired March 1. Mr. Levy served on the AIEE Chemical, Electrochemical, and Electrothermal Applications Committee (1944-52) and Industrial Power Systems Committee (1950-51).

Angus MacDonald (AM '52), chief engineer, Motorola, Inc., has been named director of engineering of both Motorola's Chicago (Ill.) Military Electronics Center and of the company's Communications and Industrial Electronics Division. Mr. MacDonald has served on the AIEE Special Communications Applications Committee (1952-53) and Radio Communication Systems Committee (1952-58).

A. R. Teasdale (AM '43, M '50), chief of avionics, Temco Aircraft Corporation, Dallas, Texas, has been named to the newly created post of director of advanced technology. Mr. Teasdale is a member of the AIEE Feedback Control Systems Committee (1952-58).

C. A. Tudbury (AM '35, M '43), research engineer for the Tocco Division, Ohio Crankshaft Company, has been appointed chief engineer of the New Rochelle Tool Corporation, New Rochelle, N. Y. Mr.

Tudbury is serving on the AIEE Electric Heating Committee (1953-58).

H. J. White (M '49), director of research and development at Research-Cottrell, Inc., Bound Brook, N. J., has been appointed secretary of Research-Cottrell. Mr. White is a member of the AIEE Electronics Committee (1952-58).

W. T. Smith (AM '40, M '46), assistant chief, Telephone Engineering Division, Rural Electrification Administration, has been appointed by Anaconda Wire & Cable Company to its Washington (D.C.) office as assistant manager sales—governmental agencies. Mr. Smith has served on the following AIEE Committees: Communication (1942-44, 1947-49); Protective Devices (1947-51); and Wire Communication Systems (1949-58).

E. A. Speakman (M '56), vice-president and general manager of Fairchild Engine and Airplane Corporation's Guided Missile Division, has been named to the newly created post of manager of planning for defense electronic products, Radio Corporation of America. Mr. Speakman served on the AIEE Electronics Committee (1955-57).

A. S. Dana (AM '18, F '48), chief engineer, Kerite Company, New York, N. Y., has been appointed consulting engineer. **R. B. Norton** (M '38), assistant chief engineer, succeeds Mr. Dana as chief engineer. Mr. Dana has served on the AIEE Insulated Conductors Committee (1948-49) and is a member of the Board of Examiners (1951-58).

J. W. Davis (AM '33, M '55), transmission and outside plant engineer, east area, Southern Bell Telephone and Telegraph Company, Atlanta, Ga., has been promoted to assistant vice-president in charge of all engineering operations of the company.

H. T. Friis (AM '20, F '41, Member for Life), completed a distinguished career of more than 38 years of radio and microwave research with the Bell System on March 1, when he retired as director of research in high frequency, electronics, and guided waves at Bell Telephone Laboratories, Holmdel, N. J.

E. A. Gilbert (AM '50) has been elected a director in addition to his duties as vice-president in charge of engineering at Radio Frequency Laboratories, Inc., Boonton, N. J.

C. E. Hamann (AM '43, M '51), manager of application engineering and product service for the General Electric Company's rectifier department, has retired after more than 46 years of service with the company. Mr. Hamann is a member of the AIEE Metallic Rectifiers Committee (1949-58).

W. E. Coleman (AM '48, M '54), of United States Steel's Applied Research Laboratory, has been promoted from division chief of the Electromechanical Engineering Division to director of electromechanical development for the United States Steel Corporation.

I. T. Corbell (AM '51), special systems microwave engineer, General Electric Company, Electronics Park, Syracuse, N. Y., has been appointed manager of microwave design engineering for the communication products department. Mr. Corbell has served on the Radio Communication Systems Committee of the Institute.

L. V. Berkner (AM '29, F '47), president of Associated Universities, Inc., New York, N. Y., has been elected to the board of directors of Texas Instruments, Inc. Mr. Berkner has been a member of the AIEE Research Committee (1947-51).

M. M. Boring (AM '52), consultant on engineering manpower for the General Electric Company, has retired from the company after nearly 42 years of service, most of it in the recruiting, training, and counselling of engineers.

Stephen Chaika (AM '45), national sales supervisor, General Switch Company, a division of Norbute Corporation, Brooklyn, N. Y., has been elected to the office of vice-president in charge of sales.

J. M. Harrer (AM '40), project manager of Argonne National Laboratory's Experimental Boiling Water Reactor, has been appointed associate director of the Laboratory's Reactor Engineering Division. Mr. Harrer is presently serving on the AIEE Nucleonic and Radiation Instruments Committee (1957-58).

H. F. Herbig (AM '23, M '39), executive engineer in the Research Division's Wire Communication Laboratory, Federal Telecommunication Laboratories, a division of International Telephone and Telegraph Corporation (IT&T), Nutley, N. J., was recently inducted into the Quarter Century Club of IT&T. Mr. Herbig served on the AIEE Television and Aural Broadcasting Systems Committee (1952-56).

G. F. Herold (M '56), has joined the partnership of Rebmann & Gay, St. Louis, Mo., which has been expanded into the partnership of Rebmann Gay Herold, Consulting Engineers.

S. P. Bartles (AM '36, M '44), project engineer, Eastman Kodak Company, has been advanced to the position of engineering associate, a designation indicating one who has made outstanding engineering contributions at Kodak. Mr. Bartles has served on the AIEE Instruments and Measurements Committee (1951-52).

C. H. Bartlett (AM '52), vice-president in charge of the Manufacturing and Repair Divisions, Westinghouse Electric Corporation, has been appointed executive assistant to A. C. Monteith, the company's vice-president and general manager of the apparatus products group.

W. F. Eagan (AM '47, M '55), engineer-in-charge of control engineering, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed chief engineer of the control department. He served on the AIEE Metallic Rectifiers Committee (1954-57).

J. M. Murray (AM '29, M '35), assistant sales manager, Simplex Wire and Cable Co., Cambridge, Mass., has been appointed sales manager.

William Olsen (AM '50), assistant manager of building wire sales, Anaconda Wire & Cable Company, New York, N. Y., has been appointed manager of building wire sales.

E. E. Paul (M '53), partner, Howard, Needles, Tammen & Bergendoff, New York, N. Y., has been elected a vice-president of the American Institute of Consulting Engineers.

J. L. Redford (AM '53), recently separated from military service, has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn., an Atomic Energy Commission installation operated by Union Carbide Nuclear Company, a Division of Union Carbide Corporation.

R. I. Kopan (AM '48), project engineer with Owens-Corning Fiberglas Corp., Kansas City, Kans., has joined the staff of Midwest Research Institute, Kansas City, Mo., as a senior engineer.

E. M. Williams (AM '40, M '47), head of the electrical engineering department, Carnegie Institute of Technology, Pittsburgh, Pa., received a Special Award in Engineering from the Pittsburgh Junior Chamber of Commerce. Dr. Williams is a member of the AIEE Education Committee (1954-58) and Petroleum Industry Committee (1957-58).

A. W. Maas (AM '39), San Francisco (Calif.) branch manager of Wagner Electric Corporation, has been appointed manager of industrial product sales for the R&IE Equipment Division of I-T-E Circuit Breaker Company, Greensburg, Pa.

K. R. Eppele (AM '52), systems division engineer, Wyle Research Corporation, El Segundo, Calif., has been promoted to the position of Laboratory director.

OBITUARIES

Comfort Avery Adams (AM '94, M '05, F '13, Member for Life), prominent engineer and past president of the AIEE, 1918-19, died recently at his home in Philadelphia, Pa. He was 89 years old. Dr. Adams was born in Cleveland, Ohio, November 1, 1868. He attended Case School of Applied Science (now Case Institute of Technology) where he received the B.S. degree in 1890, E.E. degree in 1905, and D.Eng. in 1925. He also received the honorary degree of D.Eng. from Lehigh University in 1938. In 1891, Dr. Adams joined the faculty of Harvard University where he taught for 45 years. In 1919, he served as dean of the Harvard Engineering School. He held the title of Lawrence Professor of Engineering and Gordon McKay Professor of Electrical Engineering, Emeritus. Dr. Adams also served as a consultant whose major clients included: American Tool and Machine Company,

C. A. Adams

Stone and Webster Company, Warner Sugar Refining Company, American Sugar Refining Company, Boston Edison Company, Public Service Electric and Gas Company of New Jersey, Okonite Company, General Electric Company, and others. Dr. Adams was one of 35 engineering members of the National Academy of Sciences; a Fellow of the American Academy of Arts and Sciences, the American Physical Society, and The American Society of Mechanical Engineers; a member of the American Society of Civil Engineers. He was a charter member of the Electrochemical Society and an early member of the Society for the Promotion of Engineering Education. He was also a member of the British Institution of Electrical Engineers and the Societe Francaise des Electriciens. Dr. Adams was organizer and first president of the American Welding Society (AWS), an honorary member, and first recipient of its Miller Medal. An annual feature of the AWS is its Adams Lecture. He was also organizer and first chairman of the Welding Research Council. For 15 years, he had been a member of the Franklin Institute Committee on Science and the Arts. In 1940, he received the Lamme Medal of the AIEE, and in 1956 the Edison Medal of the Institute. The latter was awarded "... for pioneering achievements in the development of alternating current electric machinery and in electric welding; for vision and initiative in the formation of an engineering standards organization; and for eminence as an educator and consulting engineer." Dr. Adams served as chairman of several AIEE Committees including: Code of Principles of Professional Conduct, Edison Medal, Executive, and Standards. He also served on the Research, Education, Electrical Machinery, Electric Welding, and other Committees. During 1924-26, he was president of the U. S. National Committee of the International Electrotechnical Commission.

Ovid Wallace Eshbach (AM '17, M '30, F '37, Member for Life), retired dean of Northwestern University Technological Institute, died recently at the age of 64. Dr. Eshbach was born in Pennsburg, Pa., and graduated in 1915 from Lehigh University. He received the M.S. degree in 1920 from Lehigh and the D.Eng. degree in 1948. He also received a doctorate in science from Ursinus College in 1939. Dr. Eshbach began his teaching career in 1916 as an instructor in engineering at Lehigh. From 1920 to 1923, he served as assistant professor of electrical engineering. He later held teaching posts at Polytechnic Institute of Brooklyn and Massachusetts Institute of Technology. Dr. Eshbach's experience in industry included service as an engineer with the Bell Telephone Company of Pennsylvania and the American Telephone & Telegraph Company, New York, N. Y. He was dean of the Northwestern University Technological Institute from 1939 to 1953 and was acting dean from 1955 to 1957. Dr. Eshbach was a member of the American Society for Engineering Education and was active in Eta Kappa Nu. In 1945, he was awarded the Octave Chanute Medal of the Western Society of Engineers of which he was president. Dr. Eshbach served on the following AIEE Committees: Education (1931-40, chairman 1935-37); Student Branches (1935-38, chairman 1935-36); Technical Program (1935-37); Publication (1935-41); Sections (1935-36); Award of Institute Prizes (1936-37); Engineers' Council for Professional Development (1939-45); and Special Committee on Collective Bargaining and Related Matters (1944-49).

William Franklin Black (AM '48), distribution engineer, Pacific Gas and Electric Company, San Francisco, Calif., died recently. Mr. Black was born on December 21, 1904, in San Antonio, Texas. He received the B.S. degree in E.E. from The Rice Institute, Houston, Texas, in 1927. From 1928 to 1937, he was employed by The Mexican Light & Power Company, Ltd., Mexico, D.F. Following this, he worked for several firms including Montreal Engineering Company, Ltd.; The Venezuela Power Company, Ltd.; San Salvador Electric Light Company; Aluminum Company of Canada, Ltd.; Aluminum Laboratories, Ltd.; and Gibbs and Hill, S.A. In 1948, he joined the Pacific Gas and Electric Company as general distribution engineer.

William F. Gilman (AM '17, M '31, Member for Life), retired electrical engineer, died recently. Mr. Gilman was born on January 19, 1883, in Mt. Vernon, Maine. He graduated from the Massachusetts Institute of Technology as an electrical engineer in 1906. From 1906 to 1907, he was with the Colon Electrical and Ice Supply Company in Panama and later took a position with the Canal Commission in Panama. Returning to the United States, he was engaged as an engineer with the Insull interests of the Midwest. After some years in this work, he went to China for the General Electric Company to install electric power in Hongkong. On his return in 1932, Mr. Gilman became general manager of the Provincetown Light and Power Company and later a vice-president and director of that organization which a few years ago merged with the Cape and Vineyard Company of Hyannis, Mass. He retired in 1955, Mr. Gilman was very active in local civic affairs.

Robert Howes (AM '01, M '11, F '13, Member for Life), consulting engineer, Seattle, Wash., died recently at the age of 82. Mr. Howes was born July 29, 1875, at Dennis, Mass. He received the B.S. degree in E.E. from the Polytechnic Institute of Brooklyn in 1897, and the M.E. degree from Cornell University in 1898. He was employed by several companies including the Washington Water Power Company, Spokane, Wash., before becoming a consulting engineer. Mr. Howes was a member of the Rotary Club, the Seattle Engineers' Club, and the Seattle Section of the American Society of Civil Engineers.

Ray Stevens Hoyt (AM '12, M '13, Member for Life), retired electrical engineer, of Chatham, N. J., died recently. He was 75 years old. Mr. Hoyt graduated from the University of Wisconsin in 1905 with a B.S. degree in E.E. He then spent a year at Massachusetts Institute of Technology as a graduate student and assistant instructor. He joined the engineering department of the American Telephone & Telegraph Company, Boston, Mass., in 1906, and in 1907 became affiliated with the Western Electric Company, New York, N. Y. In 1910, he attended Princeton University to obtain his M.S. degree, after which he returned to Western Electric. In 1947, he retired from the transmission engineering department of Bell Telephone Laboratories.

George Whelpley Millican (AM '44), assistant apparatus and protection engineer, Quebec Hydro-Electric Commission, Montreal, Que., Canada, died recently. Mr. Millican was born October 15, 1904, in Fredericton, N. B. He received the B.S. degree in E.E. from the University of New Brunswick. From 1926 to 1927, he was engaged in general apprentice work for the Montreal Light, Heat & Power Cons. at Cedar Rapids Power House. He transferred to Montreal in 1927, returning to Cedar Rapids the following year as assistant to the superintendent. In 1929, he was named assistant to protection engineer and in 1941 electrical designer, engineering department.

Jack Ralph Poore (AM '54), electrical engineer, design section, U. S. Corps of Engineers, Seattle, Wash., died recently. He was 56 years old. Mr. Poore was born in Arcola, Mo. and graduated from Washington State College. He became chief engineer for the Carlisle Lumber Company in Onalaska, Wash., and in 1941 transferred to Seattle as superintendent of the Charcoal Division of the company.

Thomas Raymond Watts (AM '25, M '34), senior engineer in the switchgear long range major development department, Westinghouse Electric Corporation, East Pittsburgh, Pa., died recently. Mr. Watts was born November 25, 1898. He attended the University of Cincinnati and graduated as an electrical engineer in 1922. He joined Westinghouse in 1929, engaging in insulation studies at the Research Laboratories. In 1941, he transferred to power circuit breaker engineering where he made major contributions to the design of high voltage condenser bushings. For the past three years, Mr. Watts was doing important insulation development work in the switchgear long range major development department, particularly in connection with new applications of the dielectric gas sulfur hexafluoride.

OF CURRENT INTEREST

ELECTRONIC WELDERS peer through microscopes to manufacture millions of semiconductors annually in their work at the semiconductor manufacturing plant of Hughes Aircraft Company in Los Angeles. Components to be welded are so small that operation must be observed under high magnification.

Fast Recovery Silicon Diodes in High-Volume Production

SILICON is one of the most plentiful elements on earth. It was isolated as an element over 125 years ago. It is interesting to note that only recently have its properties been undergoing such intense exploitation. For silicon to manifest its outstanding electrical properties, it must possess a perfect crystalline structure as well as a level of purity never before achieved in chemical substances.

A brief review of the major breakthroughs that have occurred in developing silicon to this high degree of perfection will give some idea of the magnitude of the problems that have been solved and why today the power and electronics fields stand on the threshold of a major revolution.

Silicon melts at white hot temperatures and the growing of crystals at these temperatures has been a new challenge to the technological world. This challenge was met, however, and soon silicon crystals were being grown quite routinely in laboratories throughout the United States. However, some in the industry realized that it was not enough that the crystal be single but that it had to have a degree of crystalline perfection not found in the most perfect gems. Therefore, one of the companies inaugurated a year-long program of selection and study of crystal perfection. It consisted of cutting from grown silicon crystals material that would be used for the seeds on which to grow additional crystals. The best available X-ray and metallographic techniques as well as resistivity and lifetime measurements were applied to these seed materials. Only the very best materials from all measurable parameters were accepted as seeds for growing the next family of crystals. Thus, through long and careful selection, it is possible to generate the quality of seeds necessary to grow crystals of certain required perfection.

Having accomplished a significant step on the path toward practical silicon semiconducting devices by recognizing and developing an adequate seed program, attention next was necessarily turned to the question of purity. Semiconducting materials must have purities that extend far beyond the limits of normal chemical analysis. Specifically, the best silicon must be purified until it has only one part impurity per 100 billion parts silicon. Thus, the industry was faced with the problem of eliminating impurities which they could not identify.

The only indication of the impurity was the performance of the material in a device. One of the first recognized sources of chemical impurities was the crucible which held the molten material during the growth process. Careful measurements showed that approximately three to five thousandths of an inch of the surface material of the crucible was dissolved during the growing cycle of the crystal. An analysis of this quartz showed that it contained very small amounts of impurities. A program was undertaken to obtain higher purity quartz from which to make crucibles for use in growing high purity silicon crystals of sufficient purity. This program revealed that equipment used to fabricate quartz crucibles could not be used to perform similar functions on any other material, because the vapors that deposited on the equipment from any other operation would, in turn, be redeposited from the equipment into the quartz and, thus, provide a source of contamination of the quartz that was too high to tolerate in this ever-exacting semiconducting field. This upstart semiconductor industry then put the pressure on the long-established, deep-rooted chemical industry.

With an all-out effort they developed

a superior grade of chemicals which now are called "semiconductor grade," with greater purity than the previous chemically pure materials available. The industry can be proud of that.

One might very well ask whether there are any problems still unsolved in the technology of preparing silicon for semiconducting devices. The answer is that during the last few years, considerable effort has been concentrated on what is considered to be the last major problem to be licked before silicon is considered a foolproof and readily manufacturable material.

A troublesome characteristic of silicon persisted until very recently in that when the silicon is heated to elevated temperatures during the manufacturing process of a device, it loses minority carrier lifetime—a valuable electrical property. The minority carrier lifetime indicates the distance an electron travels in the material before becoming trapped by an atom. This reduced lifetime has the effect of diminishing the amount of current that a transistor can handle inasmuch as the current is lost in transit through the device.

This deficiency in silicon has been partially circumvented in various ways by alternate device technologies but the absolute maximum of utilization of silicon still requires that the lifetime problem be solved. Significant breakthroughs in this field have appeared. It now is assumed that with continued effort one will be able to say that silicon in all of its properties is under control, and can be made by production methods to fulfill the most exacting requirements of any device. Thus, the requirements for a nearly ideal semiconducting material are reaching fulfillment.

Tremendous progress has been made but all problems are not solved. The full potential of silicon has not yet been realized and there are challenging problems ahead. Scientific research in the fast-growing semiconductor industry has been intensified to such a degree that, at least in the previously mentioned case, an important new product has been introduced to volume production within six months after its conception.

Dr. D. M. Van Winkle, head of semiconductor research and development for Hughes Aircraft Company, Culver City, Calif., told a press conference recently that "we cannot afford to spend years in a laboratory to come up with a new product." He cited the case of a fast recovery silicon diode now in heavy production at the company's Los Angeles plant.

About two years ago, it was determined that there was a growing need for just such a device in the company product line. The firm's laboratory was put to work and, within six months customers were offered the newly developed diode to use.

Dr. Van Winkle told business, financial, and trade writers that so rapid have been technical developments in silicon diodes, transistors, and rectifiers that a whole new line of these tiny products has been made available to industry in less than 4 years.

During this period of remarkable growth, scientific advancements demanded by the industry of its suppliers have had far-reaching effects in the metallurgical, chemical, and pharmaceutical fields, as previously mentioned.

Dr. Van Winkle disclosed that a program to obtain higher purity quartz from which to make crucibles was undertaken and that its success led to the present high-volume production of silicon semiconductor devices. A goodly amount of credit is due the efforts of Hughes Research Laboratories.

To a great extent they have been pioneers in a new frontier of science technology and, as a consequence and with the tremendous efforts of manufacturing technological personnel, have produced more silicon semiconductor devices than any other company in the world and silicon applications are its most important products.

Laboratories are working on still more advanced products, utilizing still more advanced basic materials, and developing still more advanced techniques for still more advanced semiconductor application in industry, in the military, as well as in the home.

Hughes Aircraft Company Photo

HOT RIDE on moving belt through electric heating coil of partly assembled semiconductors insures good electrical connections in the tiny devices, which replace conventional vacuum tubes in electronic circuits.

Control System for *B-58* Supersonic Reconnaissance Bomber

THE SUPERSONIC *B-58* "Hustler"—the world's fastest bomber—was developed for the U.S. Air Force for the primary mission of bombing and reconnaissance by the Fort Worth, Texas, plant of the Convair Division of General Dynamics Corporation.

The needle-like fuselage, supported by a triangular wing and driven by four turbojet engines, carries beneath it an equally slim disposable pod that can be a devastating bomb, a battery of cameras, or a container for electronic countermeasures.

Virtually an automatic airplane, the Hustler requires only a three-man crew; pilot, navigator-bombardier, and defensive systems operator. It is capable of altitudes and speeds (Mach 2) far beyond those of any bomber now in existence.

Although performance details are classified, it has been revealed that it provides a greater gain in top-speed advantage over the latest operational bomber than that bomber had over the Wright brothers' airplane!

Control System Development

The problem of controlling supersonic flight was begun in 1949 under a U.S. Air Force research contract by Bendix Aviation Corporation's Eclipse-Pioneer Division, Teterboro, N.J., to explore the possibilities of a system that would make possible manned flight at about three times the speed of anything then in the air.

The objective was a flight-control system that would control an airplane under all flight conditions. These included combinations of low and high altitude, subsonic, transonic, and supersonic speeds; changes in gross weight and location of center of gravity, and the presence or absence of an external "pod" such as the Hustler carries. The system must provide the pilot with the means for controlling the airplane manually under all conditions and at the same time, give him maximum performance capabilities.

The system must prevent the pilot from causing maneuvers beyond the structural limitations of the plant, provide stability augmentation, control-stick steering, atti-

PLANE PLOTTERS flight-test the world's fastest "pilot," or automatic control system at the Eclipse-Pioneer Division plant, Bendix Aviation Corporation. The engineers in the analog-computer facility are connected by headsets to a laboratory mock-up of the Hustler.

AIR RAMS equipment has been put together just to simulate mechanically the forces exerted by air on the control surfaces of the supersonic *B-58* Hustler bomber. The row of hydraulic actuators slams a force of 240,000 pounds per square inch against the trailing edge of the wing (left above). The enormous external force must be overcome by the Hustler's automatic "power thinking" control system. Engineers of the Eclipse-Pioneer Division, Bendix Aviation Corporation, have "flown" the supersonic jet thousands of hours on the flight control test rig shown.

POWER-THINKING STEERING is done by Bendix Aviation Corporation engineer who holds the stick of the automatic control system developed by the company's Eclipse-Pioneer division for the supersonic *B-58* Hustler. The stick is connected through a unique linkage system that will facilitate a further step into space in manned aircraft by translating motions of the stick through its electronically and hydraulically actuated circuits into delicate control-surface motions adjusted to varying flight conditions.

tude or altitude hold, Mach hold, heading hold, automatic approach, station-keeping, and similar functions.

Control System Elements

The control system consists essentially of three parts: sensing, computing, and actuation. Sensing includes the measuring of all data, or "inputs." These inputs come from the pilot controls and switches, airplane attitude reference system, heading and navigation data, radio guidance for range and approach, altitude and speed data from the air data system, body rates and accelerations, actuator positions and velocities, and similar information.

This sensed input information, is translated into mechanical motion and control of the airplane through the amplifier computer, power control linkage assembly, and surface actuation system interconnected systems.

Amplifier Computer

The amplifier computer is the "brain" of the Hustler flight-control system. Within a volume of 2.2 cubic feet (comparable in size and shape to a "two-suiter" traveling bag) are packed 140 transistors, more than 2,000 resistors and capacitors, three miles of wire and 10 electromechanical units containing 14 motors, 60 potentiometers, 15 synchros, and gearing with ratios varying from 900:1 to 1,235,000:1. In this unit the "commands" or signals that control the airplane are computed and distributed to other parts of the over-all control system.

Built into the amplifier computer is a "G"–limiting feature that automatically prevents either the automatic pilot or the human pilot from "commanding" a maneuver that exceeds the structural limitations of the Hustler. This is an essential aspect of supersonic flight, because a violent maneuver could disintegrate the plane. The system also permits automatic control of speed to achieve the best fuel economy (Constant Mach Mode).

Once the *B-58* is airborne, the pilot can maneuver to any desired altitude and speed and smoothly engage the automatic pilot. In addition, the pilot may maneuver the Hustler through the control stick without disengaging the autopilot. In this maneuver, the autopilot is temporarily bypassed but follows the maneuver and automatically resumes flying the plane on the new course when the pilot returns the control stick to neutral.

Heading control can be magnetic, along a radio beam, or a gyro-directed course selected by the navigator.

The system constantly computes the gross weight of the plane (including fuel present and any equipment being carried), modifies this value in terms of acceleration, and maintains Mach and altitude through automatic trim signals as part of the over-all control function.

Surface Actuation

Two separate hydraulic systems, each exerting a force of 3,000 pounds per square inch, are used to drive the control-surface actuators. Ten rams are used to move each elevon, five of these being fed from one hydraulic supply and five from the other. This servomechanism system is so sensitive that it compensates for deflections in the control surfaces caused by their sudden movement (acceleration) by the power control system. The rams and valves are manufactured by the Bendix Corporation, Pacific Division, North Hollywood, Calif.

Four rams are used to control the rudder. They are also designed to permit only one of the hydraulic systems to operate the rudder if their is a failure of the second system.

The elevon surface actuators are capable of exerting a torque of 240,000 foot pounds, approximately 6,000 times greater than the actuator torque used on airliners and equivalent to the torque output of approximately 500 Cadillac engines.

Model Studies Save Money in Designing of Flues

AMERICAN INDUSTRY is keenly aware of the problem of air pollution and spends hundreds of millions of dollars per year to reduce pollution. Many types of equipment are used from mechanical collectors through cyclone-type collectors to high-efficiency electrostatic precipitators. Although mechanical collectors remove larger and heavier particles from industrial gases, electrostatic precipitation is required to remove particles of small size from 0.1 to 40 microns.

An electrical laboratory and research department has been operated by Re-

DUST SEPARATION PATTERNS in exit flues show areas of low velocity and high turbulence. Gas is introduced from the precipitator by turning vanes. Precipitator part of model does not operate and is included in models only for its effect on gas flow, and pressure drop.

MODEL COMPONENTS are cut and assembled from Plexiglas sheets. Technician at right is completing a model of a fan housing and flue.

SMOKE STREAM introduced over bearing of rotary air heater shows turbulence because of void around bearing. Streamlining the end of the bearing to reduce turbulence will be investigated.

AIR FLOW is improved after two revisions: eliminating the sharp angle between air heater and floor of flue and by installing a perforated plate in the flue. The void on flue floor is eliminated and flow is much less turbulent. Perforated plate straightens flow before it hits plate in front of precipitator. More uniform flow to precipitator will improve efficiency.

search-Cottrell, Inc. (R-C), Bound Brook, N. J., since the discovery of electrostatic precipitation as a useful commercial process 50 years ago. Refinements in electrical precipitation have been made constantly by laboratory work, pilot plant studies, and field testing until precipitation efficiency of over 90% is common and a few have reached 99.9%.

However, precipitators have always been sold on a "flange to flange" basis. In fact, all parts of a power plant are purchased as separate units. The precipitator manufacturer usually submits a bid on the precipitator only. He does not design the flues leading to and from the precipitator and has no authority and only limited influence on flue design. In some cases, he is shown the flue design and designs the precipitator large enough to make up for turbulent flow of gas into the unit.

The precipitator manufacturer does not have any say in the design of major equipment directly preceding or succeeding the precipitator. Inasmuch as each manufacturer wants to take up as little space as possible and submit the lowest possible bid, short ducts and sharp right-angle turns are the rule.

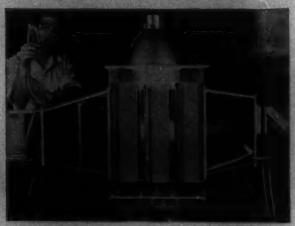
The best way to study flue design was by means of scaled working models so that gas flow patterns could be studied and velocity and pressure profiles could be obtained. Transparent plastic models were selected because of the ease of working, visibility of smoke through the plastic, and ease of making changes in models.

Two years of flue design in working models involving 10 models has indicated several areas in which dollar savings to industry can be achieved.

Decrease in Pressure Drop. The greater the pressure drop through the flues, the larger the fan and motor must be to force or induce gas through the system.

ORIGINAL DESIGN of flue section between air heater (*right*) and precipitator (*left*). Only perforated plate is used immediately before precipitator. Smoke leaves air heater floor at an angle set by angle of heater floor. Void space near floor of flue is observed. Air flow is turbulent and uneven because of shock flow caused by drastic change in cross section and angle of flow.

THIS MODEL was built to determine the best flue design for a precipitator to be built in limited space between existing equipment.



COMPLETE MODEL includes air heater (*left*), inlet flue, precipitator with three sections of plates, and collection hoppers underneath, outlet flues to stack. Smoke pattern through precipitator is uniform. Smoke has not traveled through air heater which introduces uneven and turbulent air flow.

TECHNICIAN in model shop uses a standard medical hypodermic syringe to place small quantity of special plastic solvent in joint. Joint will set up securely enough to handle in 15 minutes.

ROOM AIR is induced into the plastic model (*center*) of precipitator with air heater and flues by a 5,000 cfm fan driven by a 25-hp motor (on scaffold). Velocity and pressure readings in the model are obtained by a precision micromanometer (on table at right) and pitot tube. Smoke to observe flow patterns is generated by gas tank and equipment at left. Model partially shown at left can be connected to fan by short length of duct.

These R-C models have shown that it is possible to design flues to reduce pressure loss from ¼ inch to over 1 inch (w.g.).

Increasing Capacity of Precipitators. By bringing the gas to be cleaned to the precipitator in a more uniform manner, without turbulence and evenly distributed over all the plates, two approaches to precipitator design are possible—use of smaller precipitators to attain a given efficiency, a larger volume of gas treated in a precipitator of given size—and the capacity "safety factor" is no longer needed.

Lower Construction Costs. Studies have shown that certain components can often be eliminated, or their function replaced by less costly devices, by correctly designing a flue. Model studies showed that the drop-out hoppers increased turbulence and pressure drop and could be eliminated.

Savings in Precipitator Design. Although not properly a part of the flue design study, improvements in precipitator design have already been made. As in all research, many findings are basic and negative results are as useful as positive. For example, baffles, flow splitters, or vanes have little or no effect on guiding gas flow in three dimensions. Thus, further research with baffles has been stopped.

Most of the gas flow problems in flues involved shock patterns caused by sharp changes in flow direction, sharp changes in flue cross-section, and sharp changes in flue shape—from round to rectangular. The importance of maintaining the correct Reynolds number in shock pattern analysis has been found to be of little importance as long as it is above a critical value.

The proper utilization of perforated plates is of utmost importance because it was found that a perforated plate should not be placed in a vertical position over the opening in a hopper. In such a case, the gas flowed under the plate sweeping dust out of the hopper.

An open space or slot is commonly designed between the perforated plate and the floor of the flue to allow the moving gas to sweep away the dust that might build up at the plate. Studies are now being made of the jet effect of the slot.

Studies of costs of the models built to date indicate that the costs are nominal in comparison to the benefits which can accrue from such studies.

A model can be built in 6 to 8 weeks after preliminary drawings have been prepared. Two test engineers study flow patterns by means of threads, ribbons, ground cork, or dust. Most flow pattern studies are made with smoke. Anemometers and pitot tubes are used to take velocity and pressure measurements. Room air is induced into the models by a fan having a capacity of 5,000 cfm at 21 inches w.g. driven by a 25-hp motor. Two smaller blowers are also used.

EFFECT of a variation in placement of perforated plates on gas flow through the precipitator is determined by a velocity traverse across the precipitator plates.

Jet Engine Test Flight in ARDC Propulsion Wind Tunnel

An operating jet engine, installed in part of an aircraft, has been successfully "test-flown" inside a closed-circuit wind tunnel, the U. S. Air Force's Air Research and Development Command (ARDC) recently announced.

The tunnel can test full-scale engines or large aircraft and missile models at speeds of from 350 to 1,100 mph over a wide range of temperatures and pressures, and simulate altitudes from sea level to more than 100,000 feet.

This new concept in aeronautical ground testing laboratories was achieved in the transonic circuit of the PWT (Propulsion Wind Tunnel)—one of the three major testing laboratories at the Arnold Engineering Development Center located near Tullahoma, Tenn.

Unlike existing engine testing laboratories, this new tunnel—being a completely closed circuit—permits development testing over a wide range of altitudes at varying speeds, with fully simulated external and internal flows. Various pressure levels can be maintained because of the closed-circuit design, allowing the PWT to simulate a wide range of altitudes over the transonic speed range.

To accomplish this in an open-circuit tunnel of this size would require compressors and exhausters driven by a motor drive system of more than 1 million hp. PWT's main compressor is driven by four motors with a rated total output of 216,000 hp.

Matching an engine with a specific airplane or missile involves special problems. The efficiency of engine inlets—which must be large enough to provide the engine sufficient air, yet shaped and sized to reduce "drag"—must be determined at various altitude, speed, and flight-position conditions.

In addition, it may be found that a shock-wave from the nose or some other portion of the aircraft will be deflected into an engine inlet, disturbing its operation under various flight conditions. In the Propulsion Wind Tunnel, the engine "in flight" may be tilted up and down, or positioned in a yawed attitude to simulate the same conditions it would undergo in actual free flight. Possible loss of an expensive aircraft and crew is eliminated and valuable data can be recorded to

Future Meetings of Other Societies

Air-Conditioning & Refrigeration Institute, Annual Meeting, May 4-7, The Homestead, Hot Springs, Va.

Pennsylvania Electric Association

Engineering Section, Communications Committee Spring Meeting, May 5-6, Mountain View Hotel, Greensburg, Pa. C. E. Newhard, 901 Hamilton St, Allentown, Pa.

Engineering Section, Electrical Equipment Committee Spring Meeting, May 8-9, Skytop Lodge, Skytop, Pa. P. H. Robbins, Metropolitan Edison Co, P.O. Box 542, Reading, Pa.

The Institute of Radio Engineers

Professional Group on Microwave Theory & Techniques, 1958 National Symposium, May 5-7, Stanford Univ, Stanford, Calif. Dr. G. H. Keitel, GE Microwave Lab, 601 California Ave, Palo Alto, Calif.

National Aeronautical Electronics Conference, May 12-14, Dayton Biltmore Hotel, Dayton, Ohio. Elmer Wieland, 5200 Bradbury Rd, Dayton, Ohio.

American Institute of Mining, Metallurgical, & Petroleum Engineers, Inc.

Uranium Section, 3rd Annual Uranium Symposium, May 9-11, Moab, Utah. H. N. Appleton, AIME, 29 W 39 St, New York 18, N. Y.

Niagara Frontier Section, 3rd Reactive Metals Conference, May 27-29, Statler Hotel, Buffalo, N. Y. H. N. Appleton, AIME, same.

ASME, Oil & Gas Power Conference & Exhibit, May 11-15, Bellevue-Stratford Hotel, Philadelphia, Pa. L. S. Dennegar, ASME, 29 W 39 St, New York 18, N. Y.

EJC, Western Society of Engineers, May 19, Sherman Hotel, Chicago, Ill. EJC, 29 W 39 St, New York 18, N. Y.

American Welding Society, Spring Technical, National & Welding Show, May 19-23, Hotel Schroeder, Milwaukee, Wis.

S.A.M.E., 58th Annual Meeting, May 20-21, Washington, D. C. S.A.M.E., 808 Mills Bldg, Washington 6, D. C.

EIA (formerly RETMA), Conference on Maintainability of Electronic Equipment, May 27-28, U of Pa, Philadelphia, Pa. Engineering Office, EIA, Rm 650, 11 W 42 St, New York 36, N. Y.

6th Annual Technical Writers' Institute, June 9-13, Rensselaer Polytechnic Institute, Troy, N. Y. J. R. Gould, Rensselaer Polytechnic Inst, Troy, N. Y.

Pennsylvania State University

Seminar on electrical precipitation, June 9-13, Penn State U. Extension Conference Center, PSU, University Park, Pa.

Seminar on theory & design of turbomachinery, June 15-27, Penn State U.

Foreign

1958 British Electrical Conference, May 16-17, Belgium.

The Institution of Electrical Engineers, International Convention on Microwave Valves, May 19-23, England.

World Assembly of Association of Engineers & Architects in Israel, May 29-June 8.

CIGRE, 17th Biennial Session, June 4-14, France.

7th International Inventors Exhibition, June 6-29, Belgium.

International Organization for Standardization, Triennial Meeting, June 9-21, England.

5th International Electronic & Nuclear Energy Exposition & Congress, June 16-30, Rome, Italy. Becker & Becker Associates, 300 Park Ave., New York, N. Y.

International Electrotechnical Commission (IEC), Annual meeting, July 1-16, Stockholm, Sweden. Secy, U. S. National Committee of IEC, c/o American Standards Association, 70 E 45 St, New York 17, N.Y.

2nd International Conference for Analog Computations, Sept 1-7, Strasbourg, France. F. H. Raymond, Secrétaire Délégué Général de l' Association International pour le Calcul Analogique, c/o S.E.A., 158, Blvd de Verdun, Courbevoie (Seine), France.

solve problems on equipment already "in service" with operational flight units.

In addition to the transonic circuit, which has a velocity range of 350 to 1,100 mph, the facility has a supersonic circuit (under construction) which is designed for a speed range of 1,000 to 3,300 mph. Both circuits are part of the Unitary Wind Tunnel Plan of the United States and feature test sections 16 feet square and 40 feet long that permit testing of full-scale, operating ramjet and turbojet engines installed in pods, nacelles, fuselage sections —just as they will be in actual flight.

Helicopter Erects Power Line Transmission Tower

Several unusual uses of the versatile helicopter have been reported by Southern California Edison Company (SCE).

A Sikorsky *S-58* whirlybird was used by the company recently for such precision jobs as setting wooden distribution poles, pouring concrete, and placing huge sections of steel transmission towers—all in rugged mountain terrain.

In one spectacular operation, the helicopter even picked up a complete tower, carried it over ridges and gorges and then placed it gently on its footings several miles away.

This part of what will become a 66,000-volt transmission line linking Edison's Saugus and Chatsworth substations was built entirely without the use of access roads in the Santa Susana Mountains, it was revealed by officials of SCE.

Men and equipment were flown in first to clear each tower site and dig foundation holes. Cement hoppers were then airlifted to the sites for receiving the concrete loads, and next came the actual deliveries. Buckets having capacities of ½ cubic yard and equipped with rubberized sleeves were loaded on the ground, then attached to a hook dangling beneath the 'copter.

Enough concrete for the four footings of a tower was poured in about 20 minutes—a job normally requiring an entire day.

For joining the tower sections, engineers devised special type of "guide shoes." As the helicopter eased into position, the "shoes" clamped over the "feet" of each new section and held rigidly until it could be bolted.

In two other recent SCE construction jobs, wooden distribution poles—fully equipped with crossarms and insulators —were set entirely by helicopter.

In the Le Cumbre Peak area north of Santa Barbara, 20 poles were set in holes in the first hour of operation. Similarly, impressive time-saving figures are expected to emerge from another pole-setting operation now under way in the high Sierra.

A 16,000-volt power line is being built from the company's Big Creek Powerhouse No. 8, near Kinsman Flat, to the construction site of its $49 million Mammoth Pool hydroelectric project. The poles are being flown to positions ranging from a few hundred yards to 12 miles.

The Mammoth Pool project, which will become a part of SCE's famed Big Creek–San Joaquin River hydroelectric development, will consist of a dam 950 feet long and 330 feet hight—one of the largest earth-fill dams in the world—a powerhouse with a generating capacity of 126,000 kw, and an 8-mile tunnel. The company already operates seven powerhouses in the Big Creek area, with a combined capacity of 540,000 kw.

Polaris Missile Subs Achieve Pinpoint Navigation

A Ship's Inertial Navigation System (SINS)—key to eventual underwater launching of the Polaris fleet ballistic missile emerged from a year's highly classified testing program by the U.S. Navy as ". . . possibly the most radical advance in marine navigation since development of the compass." The testing program was conducted aboard the Navy's experimental ship *U.S.S. Compass Island*.

In a speech at the Hayden Planetarium, Captain L. L. Schock explained that the SINS is similar in principle to inertial navigation systems used in highly advanced, long-range, missile systems. The system provides ultraprecise navigation without reference to the stars, radio, radar, or other external conventional methods of navigation. Developed primarily for use in nuclear-powered, missile-launching submarines, SINS derives information from complex arrangements of gyroscopes and accelerometers and is "therefore invulnerable to known means of enemy countermeasures."

The *Compass Island*, commissioned a year ago to speed evaluation of the inertial navigation system, is the "forerunner for a fleet of submarine and surface vessels that will provide the Navy's Fleet Ballistic Missile program with the elements of mobility, concealment and readiness," according to Captain Schock.

Sperry Gyroscope Company's Marine Division (Division of Sperry Rand Corp., Great Neck, L. I., N. Y.) has developed special equipment to: (1) establish ship's position continuously, (2) measure all disturbing angular motions of the vessel continuously, (3) indicate True references (which provides precise data for missile alignment), (4) monitor the SINS by utilizing information obtained from tracking the stars, speed log, and (5) stabilize the entire vessel from roll thereby aiding missile launching and simplifying navigation and missile guidance requirements.

Pointing out the tremendous potential of a 1,500-mile Polaris missile when launched from a free-maneuvering submarine, Capt. Schock described some of the peculiar problems the Navy encountered in development of its Fleet Ballistic Missile program. Unlike land-based, long-range, ballistic missiles which have the inherent advantages of rigid stationary bases and exactly placed locations for highly accurate launching, ship-based missiles demand that the actual position of the vessel be continuously and accurately determined; that the missile guidance system and the direction of missile flight be corrected instantly under battle conditions and the severe environmental conditions of a maneuvering submarine.

The heart of the ballistic launching vessel's navigation system is SINS. Completely independent of all external references, SINS exposes nothing that would reveal the position or presence of the submarine to the enemy. It employs high-precision gyroscopes, accelerometers, and

Sadlerfoto

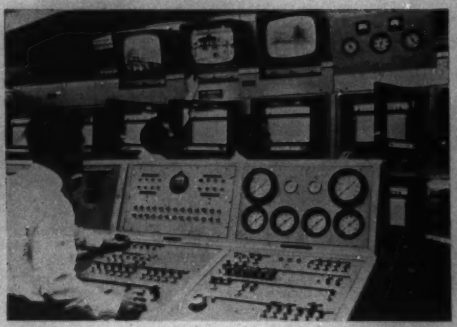
Sadlerfoto

"Dick" Wittington Photo

USING *S-58* helicopter, SCE tows assembled power poles (*left*) to prepared holes at rate of 20 poles an hour. After landing "Snowman" (*below*) at 10,000 feet elevation, helicopter leaves to ferry other hydrographers to various snow-survey points. Section of transmission tower (*right*) is lowered into specially designed "shoes" until bolted.

Static Firings Viewed from Blockhouses

ROCKET TEST site technicians clean dust and dirt from Hallamore closed-circuit television camera mounting at Aerojet-General Corporation's rocket engine test facility in Sacramento, Calif. The camera is part of a system of 36 complete camera-receiver "chains" built by The Siegler Corporation's Hallamore Electronics Co. division, Anaheim, Calif., and installed to monitor hazardous static rocket firings in the liquid- and the solid-propellant rocket plants.



MONITORED from a blockhouse at Aerojet-General's rocket engine test facility are static firings of rockets over the 17-inch screen Model *MR17BR* master control receivers; one of the largest closed-circuit television systems in the nation. Made up of 36 complete camera-receiver "chains," the Siegler Hallamore equipment features all-electrical camera controls at the viewing site, a two-way built-in sound system, and the transistorized Model CC420 camera.

integrators which continuously measure and record the minutest motions of the submarine as it journeys beneath the sea. Essentially a computer, it provides precise ship's position in latitude and longitude coordinates, true heading or course, ground speed, pitch, and roll information.

Basic to SINS is its stable gyro platform which is maintained in alignment with the stars no matter how the vessel turns and twists, rolls or pitches.

Susceptible to long-term drift, SINS is monitored by occasional reference to celestial fixes. Such information, collated by modern computer techniques, is analyzed, decoded and fed back into the system automatically by the Sperry-developed NAVDAC (navigation data assimilation center). By continuous operation of such automatic checking, the entire navigation system maintains itself in a state of constant readiness, capable of supplying, upon demand, the most correct navigation information yet devised.

Celestial navigation enables geographical position and direction of North to be determined at any location on the earth's surface, without dependence upon other navigation methods. It offers a world-wide coverage (which cannot be abridged by hostile acts), the military security of a passive system, and an exceptionally high degree of accuracy. It links astronomy, science of all that is external to earth, to geodesy, science of the earth itself.

The Polaris accuracy requirements for the measurement of star altitudes and azimuths through a periscope present a technical challenge of the highest order. The periscope, carrying the line of sight up through the pressure hull and the overlying sea water, is erratically twisted and deflected by wave slap and hydrodynamic forces. Measurements of astronomical accuracy must be conducted from a moving platform.

Radiation Device for Cancer Treatment

Another weapon in the fight against cancer and allied diseases, being tested by the Medical Division of the Oak Ridge Institute of Nuclear Studies (ORINS), is a new, double-headed radiation-teletherapy device, using two 650-curie sources of radioactive cobalt-60, thus bringing a total of 1,300 curies to bear on diseased tissue within a patient's body.

The new device, two years in the planning and construction, is the result of designs by members of the ORINS Medical Division staff and the staff of Westinghouse X-ray Corporation, which built the machine. Each head of the new device has a revolving turret on which are mounted six semipermanent collimators and one easily removable collimator, so that seven different beam sizes and intensities are readily available in each head at any time.

The two heads are mounted at diametrically opposed points on a circular frame which is free to revolve. The patient is placed on a special movable bed within the frame in such position that the diseased tissue to be treated is at the focal point of both beams. In this manner, when the frame is revolved 180 degrees, the diseased tissue receives radiation from every point in a 360-degree circle, permitting the diseased tissue to receive a large amount of radiation while the surrounding tissue and skin receive a comparatively small amount.

The machine is designed so that the bulk of the weight is close to the mechanical arc of radiation. It can utilize sources of either radioactive cobalt or cesium-137, and can use sources from other teletherapy machines whose radiation levels have decayed to the point where they are no longer practical for use in the original devices. At present, the two-headed machine is undergoing tests at the Medical Division and is not expected to be used on patients until much later in 1958.

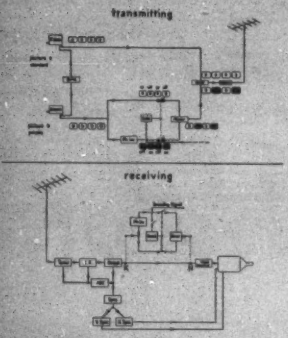
Dual Picture Television Transmission Developed

The BI-TRAN concept of television transmission, began in 1950 in a small loft in Yonkers, N. Y. It was developed by Isaac Blonder, a physicist, and Ben Tongue, an electronics engineer who established the laboratories which bear their names. Imaginative research and design of television distribution systems and components, test instruments, high fidelity components, and industrial telemetering preceded this newest concept in transmission.

In 1955, Blonder-Tongue Laboratories, Newark, N. J., introduced the *TVC-1* television camera, designed for closed-circuit and industrial applications. This was followed by the *TVC-1A* camera, available as part of a complete closed circuit television system suitable for many applications. A unique component of the systems is the automatic light compensator which assures a high-definition picture despite wide variations in light intensity and, therefore, eliminates the need for automatic iris diaphragm lens control.

The new television transmission system, called BI-TRAN now makes it technically possible to transmit 2 programs simultaneously on any television channel. It is most important to remember that this system is compatible, to the extent that it will not disrupt standard television broadcasting, but will add a new service to it, without requiring additional television channel space.

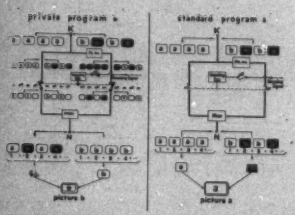
This multiplexing system transmits 2 different programs at the same time. In-



BI-TRAN transmitting and receiving systems for simultaneous broadcast of two programs.

dividual pictures are shown on their own "studio" monitors. Either program on the channel can be selected, at will, by the modified television set marked "home" receiver so that the "a" or "b" picture becomes visible.

The BI-TRAN concept requires that two different pictures be transmitted simultaneously, one a standard program, and the other a private program. The polarity of the private program is reversed



MULTIPLEXING system showing compatability of method for use with standard television broadcasting. Polarity reversal of one of the signals is effected in the decoding box at a rapid predetermined rate.

at a rapid predetemined rate. In television, polarity reversal means that black becomes white, and white becomes black.

With BI-TRAN one program is visible on the television screen as usual. The other program, being periodically reversed in phase, cancels itself out and is rendered invisible to the eye.

To view the private program, a special decoding circuit is required at the receiver to reverse the process. That is, the private program is flashed onto the screen at the standard polarity and becomes visible. The standard program is now periodically reversed in polarity and cancels.

An economic opportunity for public service television to participate actively in television broadcasting is offered by BI-TRAN. Federal, state, and local law enforcement agencies would be able to televise pertinent information to appropriate groups and to the public.

The development of BI-TRAN enhances the status of ultrahigh frequency which could continue to function as a vital means of television communications in those areas where very high frequency is not available, because it can be applied to any television channel in either band.

Viewers in the medical profession would not be required to leave their offices or homes in order to benefit by the special programs offered. New surgical techniques, tours of hospital facilities, introduction and explanation of the use of new equipment and medicines, lectures, etc.—all of these would become available to those in the medical profession. When used with network facilities, BI-TRAN would be viewed nationally on the "a" half of the channel.

Application to industry would be possible if the company bought time for "b" channel use. A given plant with nation-wide facilities could televise new processes and techniques to key personnel across the country and for the consumer, product demonstrations, stockholder meetings, and similar functions become available.

Growing Government and military requirements can solve the already tight commercial channel allocations problem with the "b" channel feature. Observers would be able to inspect maneuvers taking place in any part of the country. Intra-service communications of a classified nature would be possible. Unauthorized persons would not be able to decode these communications.

Civil defense units, locally and nationally, would have the opportunity to reach millions immediately.

Revitalized educational program must make use of mass communications. Educational television, one of the stepchildred of the medium, will be capable of providing the service long denied both the educators and the public through the use of BI-TRAN.

Educators would be able to present the best teachers before the greatest number of students for each classroom session. Adults who desire to embark on or finish high school or college educations would find it convenient to do so without the need to attend classroom sessions at the institutions.

The BI-TRAN system would enable each television channel to transmit "a" and "b" programs which are the answer to a vexing broadcasting problem—need for additional channel space.

▼ TEST SETUP of new BI-TRAN system.

Continuous Casting of Tough Pitch Copper Cakes

The world's first commercial unit to cast tough pitch copper cakes continuously—the huge slabs from which copper sheet and strip are rolled—has been installed by American Smelting and Refining Company at its Perth Amboy, N. J. (Asarco), refinery. Asarco's new process, regarded as a major breakthrough in nonferrous metallurgy, permits casting of copper cakes up to 25 feet long by 36 inches wide and weighing over 17,000 pounds. Capacity of the new multimillion dollar cake casting installation is in excess of 160 tons of copper per 8-hour shift.

Particularly significant is the size of the copper cakes which are now being produced by the unique casting procedure. With the longer lengths now available to them, copper rolling mills will be able to roll more copper per hour, with a consequent gain in plant efficiency and reduction in operating costs. Moreover, the metal cast by the new method is unusually sound and dense and has a surface uniformity which is ideal for rolling. These factors contribute to quality improvement of rolled copper sheet and strip.

The Asarco casting technique is unique in concept and revolutionary in design. It eliminates batch casting in costly, old-style individual metal molds by use of a small, "bottomless" water-cooled graphite mold. Molten copper is poured continuously into the mold cavity, is cooled so rapidly that it solidifies as it passes through the mold, and emerges from the orifice as a smooth, dense copper cake.

The mold is the key element of the process. It is only 15 inches deep, but it has been designed by Asarco engineers so that it has a heat dissipation rate of about 1,500 hp. This is believed to be the highest heat capacity per square inch

of surface of any mold ever built for either ferrous or nonferrous casting. The design enables the mold to solidify molten copper cast at 2,100 F, as it traverses the mold's 15-inch depth at a speed of up to 20 inches per minute for a 5- by 36-inch cake. This is equivalent to 1,150 pounds of copper per minute.

The mold design eliminates the need for mold preparation compounds such as are used in conventional water-cooled copper molds. To prevent sticking of the cast copper to the mold, and to ensure a smooth cake surface, the entire mold assembly is oscillated by a reciprocating gear. The vertical stroke is only a fraction of an inch and the variable speed driving motor can operate up to several hundred cycles per minute.

One of the limitations imposed on the size of the optimum quality cakes that can be turned out by old methods is that they must be vertically cast. (That is, the metal must be cast along the major axis, in this case the length of the cake—like pouring liquid into a tall column; horizontal casting, on the other hand, can be compared to pouring liquid into a shallow trough.) Horizontal casting is not practicable because the quality of the cake surface, which is of paramount importance to rollers, is impaired.

From the company's point of view, to cast tough pitch copper cakes vertically more than about 37 inches deep by old batch methods is disadvantageous because of the quality deterioration experienced (e.g., from metal splashing).

However, a 37-inch length cake, even of top quality, is far from ideal for many modern rolling mills. In recent years, many mills, confronted by higher labor costs, have installed larger, faster rolling equipment. But they have not been able to utilize these modern facilities at maximum efficiency and most economically, with the cake sizes available. Longer cakes, ideally only 5 inches thick, were the real need of most mills since these permit the production of the maximum quantity of sheet and strip per hour with a minimum number of passes through the rolls. This development has solved the basic problem of the industry. Continuous cast cakes, up to 25 feet long, in the thin dimensions desired, can now be made in widths of 25, 30, and 36 inches.

The mold is situated at ground level at the mouth of a specially constructed, 61 foot deep, water-filled well. As the solid cake emerges from the bottom of the mold, it is cooled by a series of high-speed water-spray jets. It then is lowered continuously into the reservoir of cooling water.

The cooling water is circulated by an 1,800 gallon per minute pump. As one precautionary measure, a duplicate pump is installed in the system which will cut in automatically if the operating pump should fail. In addition, a 500 gallon per minute emergency pump operating from an independent power source will take over in case of primary power failure.

After the cake is cast, the mold is swung to one side and the 25-foot, 17,000 pound cake is lifted by a 10-ton crane to a nearby platform. There, it is sawed to the precise lengths which are specified by customer rolling mills. The saw, of unusual capacity, cuts through the cake at a speed of 4 feet per minute.

COMMERCIAL UNIT to cast tough pitch copper cakes in excess of 160 tons of copper per 8-hour shift is installation at the Asarco plant. Molten copper from holding furnace (center) flows into the special pouring ladle and through the distributor into the mold. Operator in the electronic control booth governs the entire casting operation.

All three operations—continuous copper melting, cake casting, and billet casting—will be integrated operations by June. The melting furnace will provide the molten copper for cakes, billets, and, in addition, for the company's new Perth Amboy wire bar casting wheel.

The furnace has a bath capacity of 90 tons of molten copper and is designed to melt copper cathodes at a 30 ton per hour rate. Currently, the 8,000-kva furnace is operating substantially in excess of rated melting capacity.

Aircraft Running Lights Identified for Moon Watchers

With the United States satellite "Explorer" passing overhead on regular schedule, it appears that "moon-watching" is about to become a popular pastime.

The Civil Aeronautics Administration (CAA), U. S. Department of Commerce, reports an increased number of inquiries concerning "those lights in the sky." It appears that aircraft running lights, at high altitudes, sometimes raise false hopes in "moon-watching" circles.

As an assist to moon watchers, the CAA offers the following information on aircraft running lights:

Following the custom of the ships at sea, every aircraft carries a red light on the left (port) wing tip and a green light on the right (starboard) wing tip. On the tail a red and white are shown. The red light is an addition to the customary white stern light of ships.

On some aircraft these lights flash in sequence, on others they do not. The CAA added that many aircraft are now being equipped with a rotating red light mounted on the fuselage top and bottom or on the tip of the tail.

Advance in Gyroscope Accuracy

Achievement of gyroscope systems for stabilizing and guiding missiles, aircraft, and sea vessels has been made possible by development of "frictionless" gyros with near perfect preciseness. This development of Sperry Gyroscope Company located in Great Neck, L. I., New York, hinges on a unique method for controlling ball bearings within "simple" gyroscopes.

In this new development titled "Rotorace," the principle eliminates error-producing torques in gyro gimbals, the major cause of random drift error in the critically important direction-sensing devices, without significant increase in weight, cost, complexity, manufacturing or maintenance problems. Improvement has been made in random drift error by as much as 1,200%, slashing the rate to about 0.25 degree per hour from three or more degrees hourly.

The high accuracies afforded by Rotorace gyros have been effected through constant controlled rotation of the ball bearing in each of the gyro's two gimbals, which averages and minimizes bearing friction, averages "out" the errors caused by minute irregularities, and prevents pitting and wearing of certain balls in each bearing. Rotation of the bearings, being built by the New Departure Company, is accomplished by means of a minute electric motor and gear train within a gyro's housing.

Rotorace gyros are being employed for the U.S. Air Force in the design of a revolutionary Twin Gyro platform, heart of all-attitude navigation fire control, and flight control systems in high-performance aircraft. Sperry is evaluating the Rotorace principle for application in guided missiles and naval systems requiring great accuracy without greater increase in complexity. Company engineer-scientists are

CLOSE-UPS show how Sperry's "Rotorace" principle is utilized in small cylindrical motor (left). Cluster of three smaller gears transmits motion through a shaft to bearing on opposite side of gyro (right).

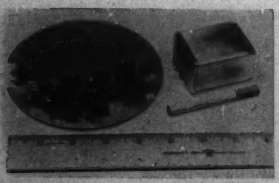
conducting extensive research to develop mass-producible gyros with additional improved wheels and wheel suspension systems, to match the bearing error cancellation provided by Rotorace. This is expected to provide even greater accuracy at relatively low cost.

Transistor Transmitter Developed for Satellite Radio

Future United States satellites can continue broadcasting outer space data to Earth 1½ to 4 times as long as is presently possible, as a result of the development of a new transmitter by engineers of the DuKane Corporation, St. Charles, Ill., under contract to the Naval Research Laboratory.

The transmitter was developed as a 500-milliwatt version of the Naval Research Laboratory's 100-milliwatt satellite transmitter. In designing the new transmitter, the DuKane engineers achieved a better efficiency as well as the desired power level. They emphasized that although the circuit works and works well, months of extensive development and testing will be required before it can be programmed into an actual satellite.

The crystal-controlled transmitter employs three recently developed Western Electric transistors capable of operating as oscillators or amplifiers at 108 mc. The special circuits employed give much greater over-all efficiency than is now possible with vacuum tubes.



BROADCAST STATION smaller than cigarette pack will be placed in satellite as radio transmitter. Developed by DuKane, unit weighs less than 3 ounces. It develops 550 milliwatt broadcast power. Version at left shows how transmitter would fit into a satellite or missile. Optional packaging at right would put powerful transmitter in compact unit which could fit into shirt pocket.

In satellite programs, this means a highly significant saving in weight, inasmuch as fewer batteries can do the same amount of work. Or, using the same batteries, the satellite transmitter can broadcast for a much longer period of time.

The tiny "broadcasting station" occupies less than 6 cubic inches of space. For a power output of 500 milliwatts, it uses one half to one fourth the battery power needed by any other transmitter now known.

The efficiency of the new transmitter could facilitate getting a rocket to the moon by substantially reducing the payload requirements. DuKane engineers say the transmitter can be operated on solar batteries, drawing its power from the sun and sending out its signals indefinitely, but with one half to one fourth of the rocket surface heretofore required for sun exposure.

By contrast to a conventional transmitter, the output stage of the new transmitter needs only 930 milliwatts power to produce the same output. The corresponding efficiencies are 11% and 54%. As an additional advantage, this circuit operates on a single 20- to 24-volt battery, whereas a tube-type transmitter requires two different types of batteries, a low-voltage filament and a high-voltage plate supply.

Weather Warnings To Be Broadcast by Conelrad

Plans are being pushed to use the radio and television CONELRAD attention signal to notify listeners of emergency storm and flood warnings, the Department of Commerce Weather Bureau announced recently. This new warning system became possible following a recent order issued by the Federal Communications Commission (FCC) which authorized this special use of the existing national defense CONELRAD alerting procedures.

Although designed for national defense purposes, CONELRAD hereafter can also be used to distribute Weather Bureau warnings of impending natural disaster, such as may threaten when a hurricane suddenly changes course, or when a violent tornado approaches a city, or when a flash flood builds up from torrential rains and rushes down a river valley.

The CONELRAD attention signal was designed so that a warning could be broadcast by all radio and television stations at the beginning of a defense alert. This unique attention signal is given by discontinuing the normal broadcast program, turning off the station's power (or sound only, in case of TV) for 5 seconds, then on for 5 seconds, then off for 5 seconds and on again, and then broadcasting a steady 1,000 cycle tone or beep for 15 seconds.

The CONELRAD attention signal will be used as follows when a weather disaster threatens: Upon request of the responsible Weather Bureau office, broadcast stations serving the threatened communities will (1) interrupt normal programs, (2) broadcast the CONELRAD attention signal, (3) transmit the Weather Bureau's emergency weather warning on their normal broadcast frequencies, and (4) then resume their scheduled programs.

All listeners are reminded that when the CONELRAD procedure is used for "weather warning emergencies" the radio stations will remain on the air and will broadcast the warnings on their normal frequencies. This procedure is in contrast to a "defense alert" where radio and television stations go off the air and any transmissions thereafter are made only on the special CONELRAD frequencies of 640 and 1,240 kc.

The Weather Bureau plans to ask radio and television stations to transmit the CONELRAD attention signal ahead of weather warnings only in the most serious emergencies.

Radio set manufacturers have been advised of this new public service aspect of CONELRAD and it is expected that many future models of radio receiving sets will contain an automatic alarm feature.

Atomic Energy Progress Summarized

The U. S. Atomic Energy Commission has made public its Twenty-third Semiannual Report to the U. S. Congress. Excerpts from the report concerning activities at Argonne National Laboratory follow.

Progress in the Peaceful Uses

Progress with Power Reactors. Since 1953, the AEC and its contractors have completed design and construction of six experimental power reactors, industry with its own funds put a seventh in operation; an eighth constructed for the Army has civilian uses. Further, an experimental reactor is operating with a new type of core. This is in addition to the successful demonstration of three nuclear-powered submarines, and the major program to build a nuclear-powered navy. The experimental reactors were built to advance the technology of various types of power plants, each of which has been detailed in previous issues of *Electrical Engineering*. These reactors are not, of course, producing power at costs that are competitive with those of power plants using conventional fuels. But one, the Experimental Boiling Water Reactor (EBWR), has operated at 2½ times its design power level. These, and other plants of advanced design being designed or built, will help determine the technical feasibility and economic promise of various reactor types.

1953-57 Highlights. During 1953, the AEC demonstrated with the Experimental Breeder Reactor No. 1, the first nuclear reactor to generate electricity (December 21, 1951), that breeding of nuclear fuels in a reactor was definitely feasible, and that the reactor was producing at least as much fissionable material as it consumed. During 1954, a reactor training school at Argonne was established and steps were taken to provide scientific and technical training for foreign nationals

and to launch a program donating technical libraries to foreign countries. During 1955, the third boiling water reactor experiment, BORAX 3, supplied the town of Arco, Idaho, with all its power and light requirements on an experimental basis on the night of July 17. During 1956, the Experimental Boiling Water Reactor (EBWR) and the BORAX 4 reactor were completed and in operation; construction advanced of three other experimental power reactors; plans completed for the Organic-Moderated Reactor and the Experimental Breeder Reactor No. 2; and studies made on four other reactors of more advanced types, as well as research on fuel processing, reactor safety, and waste handling. During 1957, the AEC licensed operation of General Electric's Vallecitos power reactor, pilot plant for a large commercial central power station, producing electricity on an experimental basis, distributed by Pacific Gas & Electric Co. Two other major private nuclear power plants were under construction, one near Joliet, Ill.; and the other at Indian Point, N. Y.

Progress with Radioisotopes

Radioisotopes in Medicine and Agriculture. Knowledge gained by the use of radioisotopes in medical diagnosis and therapy, and in related basic studies, and in many agricultural fields has expanded steadily since 1946 when reactor-produced radioisotopes first were made available in quantity. In the field of cancer research, efforts are being made to use radioisotope-labeled antibodies against cancer cells. The latest and largest cancer research facility, Argonne Cancer Research Hospital, is operated for the AEC by and located on the campus of the University of Chicago. Studies at the Radiological Laboratory, University of California, San Francisco, and with the 2-Mev Van de Graaff electrostatic generator at the Argonne Cancer Research Hospital are evaluating the use of supervoltage equipment. Pituitary irradiation has also been accomplished at the Argonne Cancer Research Hospital through a unique application of irradiated yttrium pellets implanted surgically in human patients.

Progress with Power Reactors

The reactors (operated and developed by Argonne) in operation at the end of 1957 were EBWR, AEC, at Lemont, Ill., 5,000-kw output, critical December 1956; EBR, No. 1 (Mark III core), at NRTS, 200-kw output, critical November 1957; and site preparation began and components were ordered for the Experimental Breeder Reactor No. 2 at the National Reactor Testing Station.

Technical Problems of Economic Reactors. Progress in the civilian atomic power effort requires extensive operating experience. The program is just a little over 3 years old and the initial experimental reactors have just been completed. Nevertheless, there has now been sufficient experience to identify basic problems which must be solved before economic nuclear power will be achieved.

Reduction in Capital Costs. It is expected that capital costs will be reduced by simplification of design, by increased use of standardized components, by adoption of commercial specifications and fabrication techniques, and by multiple production of components. Unit capital costs will be reduced when performance is improved and larger plants are built.

Projects Planned for Argonne National Laboratory

Authorization has been given to the Argonne National Loboratories, Lemont, Ill., by the Atomic Energy Commission (AEC) to construct a Fuels Technology Center at the loboratory site, and Experimental Breeder Reactor No. 2 (EBR-2) at the National Reactor Testing Station (NRTS), Idaho Falls, Idaho.

The fuels facility will enable Argonne scientists to speed up and expand their efforts to develop technology to permit use of plutonium as a fuel in nuclear reactors. A highly radioactive element, plutonium is also chemically toxic. It is the first transuranium element produced in a nuclear reactor and isolated on a large scale. At present, fabrication of these fuel elements of various sizes and shapes for nuclear reactors is being done in temporary facilities.

Argonne scientists are working on the plans for the EBR-2, and expect to place it in operation in 1960 at the NRTS. The breeder type reactor is one of the original five types of reactors being developed under the AEC's civilian power reactor development program.

The proposed EBR-2 will have a thermal output of 62,500 kw and a net electrical output of 17,500 kw. In the beginning, it will have a U-235 alloy core which will be designed so that a plutonium alloy core can be substituted later. The EBR-2 is a prototype of a large-scale fast breeder reactor.

The Fuels Technology Center will also be equipped with modern metallurgical facilities for fundamental research and engineering studies of uranium, thorium, and many other metals of interest to nuclear power reactor specialists.

Argonne National Laboratory is operated by the University of Chicago under contract to the U. S. Atomic Energy Commission.

Seaway Power Neoprene Protected

The electric power source, used to operate two 350-ton traveling cranes on the Iroquois Dam of the St. Lawrence Power Project, is being protected from the weather by a curtain of neoprene synthetic rubber. Similar curtains were installed this Spring on the two other dams located in the International Rapids section of the Seaway. The neoprene weather shields will be permanent fixtures.

These gantry cranes, used primarily to lift the 32 sluice gates that control the backwater level, receive electric power from a bus bar carrying 550 volts. The bar, which runs the length of the dam, is

ALONG THE TOP of Iroquois Dam, two 350-ton traveling cranes move along.

enclosed in a metal housing. One side of the housing, where the crane's arm reaches in to contact the bar, is protected by a thick curtain made of nylon reinforced neoprene.

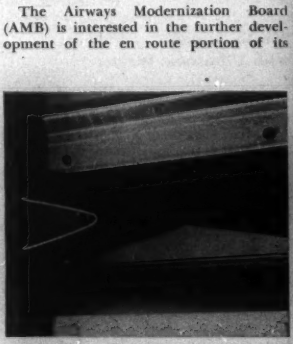
The curtain consists of two interlocking strips, 1,970 feet long, weighing a total of 10,000 pounds. The joint is of tongue and groove design. The contact arm lifts the upper strip out of the groove as the crane moves along the top of the dam. The flexible curtain snaps closed automatically as the arm passes.

Produced commercially for 25 years by the Du Pont Company, neoprene offers excellent resistance to aging and weather. In addition, it remains flexible in cold weather, even at the —50 F temperatures that have been recorded along the St. Lawrence.

Iroquois Dam, completed in the Fall of 1957, will maintain Lake Ontario at its natural level. In the Spring, the curtains were installed on the Long Sault Dam, 2,900 feet long, and the St. Lawrence (Barnhart) Power Dam, which is approximately 3,120 feet long. Both Iroquois and Long Sault, along with the United States half of the power dam, are being built by the Power Authority of the State of New York.

Monitor for Jet Age Traffic

The Airways Modernization Board (AMB) is interested in the further development of the en route portion of its



CONTACT ARM, located on crane leg, extends through neoprene curtain to reach electric power bar carrying 550 volts. It is shown in closeup pushing up the curtain.

experimental semiautomatic data processing system for air traffic control and has asked General Precision Laboratory, Inc., Pleasantville, N. Y., a subsidiary of General Precision Equipment Corp., to undertake this job.

Sufficiently flexible in design to function with existing procedures and facilities as well as future changes, the system provides for the reception, correlation, computation, display, and exchange of air traffic control information. It performs automatically the routine nondecision-making functions for the air traffic controller, presenting the information required for his decision. Based on data obtained from previously prepared flight plans and those submitted in flight, the system automatically monitors the available air space to provide safe, expeditious air traffic control and makes a continuous and automatic check for potential conflicts. Provision is included for the use of air-route surveillance radar and for transmission of air traffic control information to the Air Defense Command.

Automatic aspects of the system include preparation from filed flight plans of flight progress strips which are distributed to the active controllers and automatically up-dated after posting on the flight progress boards. A fail-safe feature permits the use of these same strips at any time the system reverts to manual control methods. A special flow control panel for the use of the air traffic control supervisor allows him to make adjustments of traffic direction and rate, taking into account such varied factors as weather information, airport traffic conditions and capacity.

The computer portion of the system can process as many as 400 flight plans per hour and has a total storage capacity of 1,000 plans. The equipment can print and distribute 1,600 flight progress strips in an hour and can process for up-dating purposes an equal number of position reports and other revised flight data.

Installation of the initial model of the new system is scheduled for the New York Air Route Traffic Control Center in the early part of 1960 following an intensive simulator test program.

Metals Joined with Ultrasonic Welder

An automated, continuous seam, ultrasonic welder produced by Gulton Industries, Inc., Metuchen, N. J., was developed as a result of a research contract and built to exact specifications to be used in a classified project. Through high frequency sound alone, the welder joins any two dissimilar or similar metals as a result of a molecular transference or plastic flow at the interfaces of the two metals and below the melting point of either metal. Similar in performance to standard electric seam welders, the completely automatic machine achieves a speed rate of 200 inches of welding per minute, and can accomplish this with aluminum, which previously was impossible.

Although it was designed to produce 30 inch seams and weld corrugated sheets to long curved aluminum extrusion, it can be adjusted to produce any length seam and weld both flat and semi-circular sheets. Standing 13 feet high, 12 feet long and 10 feet wide, the ultrasonic welder weighs roughly three tons. It is powered by two 2-kw generators which operate alternately, depending on the forward or backward motion of the welding heads, and supply 500 watts of power to each welding head. A self-monitoring instrument, it will automatically shut down if

Ostergaard Photograph

VIEW of welding heads showing barium titanate transducers and aluminum horn that acts as a mechanical step up transformer of 20-kc signal. Horn is tuned to full wavelength at longitudinal mode. Welding tool is tuned to ½ wavelength, carries energy to the interface.

failure occurs, in which case a control board of panel lights is used to locate the defective part. Its eight welding heads, four operating simultaneously, are driven ultrasonically in the approximate range of 20,000 cycles. With ultrasonic welding, the need for degreasing is minimized.

Immediate applications include the welding of airframes and skins for missiles and aircraft as well as components to be used inside these vehicles where minimum weight restrictions must be observed.

Giant Turbines for Swedish Power Plant

Powerful water turbines are at present being built at Nydqvist & Holm, Trollhättan, Sweden, for the Swedish State Power Board's Ume River 380,000-kw Stornorrfors plant. The station is planned for an annual output of 2,200 million kw-hr.

When fully completed, this plant will utilize a flow of 28,000 cubic feet per second. However, present plans foresee the harnessing of three quarters of this capacity through the installation of three aggregates, each for 7,000 cubic feet per second.

Each turbine, of the Francis type, is to have a guaranteed rating of 178,060 hp at a head of 240 ft. which can be raised to 200,000 hp at 246 ft. The dimensions will be unusually large. The runner, weighing 70 tons, has a 17-foot OD, and the 36.5-ton turbine shaft has a 13 foot length.

The runners are made from cast stainless steel and welded. After welding, the units are heat-treated to eliminate welding stresses. For this purpose, the company has installed a giant tempering furnace, which is the largest of its kind in Sweden.

The Stornorrfors plant, which is to be completed by 1959, expects to start operation by late 1958.

International Analog Computations Conference

On September 1, 1958, the International Association for Analog Computations, founded in 1955, will hold its second International Conference in Strzsbourg, France. Scheduled to last one week, the conference will be devoted to the various systems of analog computations, their numerous applications, and the connections between the analogical methods and the arithmetical methods of computations in electronics.

Detailed information on the projected conference may be obtained from F. H. Raymond, Secrétaire Délégué Général de l'Association Internationale pour le Calcul Analogique, c/o S.E.A., 138, Boulevard de Verdun, Courbevoie (Seine), France.

South Pole Temperature Observations

The South Pole receives more sun than any place on earth during December, its midsummer, but most of this energy is reflected by the ice cover, a scientist just returned from the Antarctic stated.

Dr. Herfried Hoinkes, an Austrian meteorologist whose studies were made as part of the U.S. International Geophysical Year (IGY) program, told U.S. Weather Bureau and IGY personnel that preliminary findings show about 89% of solar energy received in the Antarctic is lost through such reflection.

Absorption of radiant heat is slow because of the fine grain of the top snow layer, Dr. Hoinkes reported. This layer is so hard that he walked on it without leaving footprints. Where prints were left, they remained sharp for weeks, indicating the small amount of evaporation.

Dr. Hoinkes' 3,664 temperature observations over a 5-month period at the IGY Little America Station indicated that under the most common wind conditions —southeasterlies of 19 knots—temperature difference between the surface and 50 feet above was only 1 to 3 degrees. The maximum temperature inversion, where, as Dr. Hoinkes put it, "your nose was 20 degrees warmer than your feet," occurred under clear skies and calm wind conditions, because of the strong long-wave radiation from earth to sky.

When a cloud cover moves in to block heat loss from the earth and at the same time emit the heat it has collected, a rapid warming of the surface takes place even in winter.

Minimum possible Antarctic temperatures of —108 F have been calculated from observed radiation loss by both Soviet and American meteorologists participating in the IGY program, Dr. Hoinkes said. Actual minimum observation at the

U.S. South Pole station in 1957 was —102.4 F.

Dr. Hoinkes is chief glacial meteorologist for the Arctic Institute of North America, a private nonprofit organization performing research sponsored by the IGY Committee of the National Academy of Sciences in Washington, D.C.

The IGY Antartic program in which Dr. Hoinkes participated receives extensive logistic support from the U.S. Navy Task Force 43, commanded by Adm. George Dufek.

Artificial Muscle for Paralyzed Hands Developed

An artificial muscle that makes possible the use of paralyzed hands was announced and demonstrated before a conference of the New York Academy of Sciences.

There are 50,000 persons in the United States with polio-paralyzed hands who can be benefited by the discovery, according to Dr. K. S. Landauer of the National Foundation for Infantile Paralysis.

Dr. Landauer reported on the artificial muscle, which he described as the first major forward step outside the respiratory field, before 110 scientists and physicians.

The "hand motivator," as Dr. Landauer describes it, employs a unique artificial muscle to control grasping and release movements of the thumb and first two fingers of the hand. The muscle is made of nylon fiber, woven in a special geometric pattern, enclosing a length of rubber tubing.

Compressed carbon dioxide gas, the flow of which is controlled by a simple switch fills the tube and causes the nylon to contract. Emptying of the tube relaxes the grip. The device is a simple metal harness which fits, somewhat like a splint, over the forearm, thumb, and two forefingers. The muscle lies along the outside of the arm, between elbow and knuckles. The muscle transfers energy to the thumb and fingers with normal hand-grip intensity, thus eliminating the possibility of overcontraction of the muscle which might damage the hand. Size of the muscle determines its contractibility. Gas pressure, regulated by the valve, determines the strength.

The invention is so simple, and will be sufficiently inexpensive so that anyone with a paralyzed hand can be outfitted. A major element in the cost would be the need for special fitting of the harness to the individual arm and hand.

The artificial arm muscle, which undoubtedly would be followed by others to restore functioning activity to other muscles, was designed by Dr. J. L. McKibben, a University of California experimental physicist stationed at Los Alamos Scientific Laboratory. Dr. McKibben also aided in designing the valve which controls tension in the hand grasp. This can be varied from a touch light enough to manage a cigaret or lipstick to a grip sufficient to grasp and manipulate tools.

Other scientists who aided in development of the device are Drs. V. L. Nickel and Jacquelin Perry, and Roy Snelson of the Los Angeles County Rancho Los Amigos Respiratory and Rehabilitation Center for Poliomyelitis.

This work was done with the aid of a grant from the National Foundation for Infantile Paralysis where Dr. Landauer is director of respiratory and rehabilitation center services. The conference at which his report was given was called by the New York Academy of Sciences to evaluate "Contributions of the Physical, Biological, and Psychological Sciences in Human Disability."

Temperature Chamber Tests Armament Systems

Temperature extremes are being duplicated by engineers and technicians of Westinghouse Electric Corporation to test the ability of automatic armament systems for U. S. Navy and Air Force planes to work anywhere regardless of environment. The environmental test chamber is installed at the company's Friendship Airport plant in Baltimore, Md.

Such equipment as radar and computers, which make up the all-weather fire control systems, are placed in the massive 10-foot high weather chambers,

TECHNICIANS roll Navy interceptor's nose assembly containing electronic gun-aiming equipment into Westinghouse altitude-temperature test chamber. Seen at left is the humidity chamber.

where salt spray and humidity-temperature conditions are created. Behind seven thicknesses of glass, complex electronic equipment is subjected to temperature ranges from —105 F to +500 F and humidity approaching 100%.

The new apparatus, resembling a two-car garage, is heavily insulated and lined with stainless steel. The altitude-temperature chamber, which has an eight-ton door, is capable of conducting rapid temperature changes by heating or cooling air in a separately enclosed area above the test area. When the rapid change is desired, trap doors in the ceiling are opened and fans circulate the hotter or colder air into the main section.

Kitt Peak Site of New Astronomical Observatory

Kitt Peak, in the Quinlan Mountains, about 40 miles southwest of Tucson, Ariz., was approved by the National Science Foundation (NSF) as the site for the new National Astronomical Observatory. The site was recommended to the Foundation by its contractor, the Association of Universities for Research in Astronomy, Inc. (AURA), which is responsible for the construction and operation of the new observatory under a contract with the NSF. The site was selected after a three-year study by a team of astronomers. Starting initially with some 150 sites in the southwestern United States, the choice was gradually narrowed to five sites, where extensive tests were made.

The Kitt Peak site is at an elevation of 6,875 feet and has a flat area of 70 acres on the summit, usable for an observatory and auxiliary buildings. Observations were started on the site in January 1957. Equipment used to test the site includes a 16-inch equatorial telescope.

The District and Tribal Councils of the Papago Indians, on whose reservation the mountain is located, have indicated their willingness to have the site used for scientific purposes. Kitt Peak is sacred to the Papagos, but in the interest of science they consented to having it tested for "seeing" and have been co-operating with the scientists working at the site.

Kitt Peak is sufficiently distant from Tucson to be free from the majority of types of man-made interference. At the same time, the relative proximity of Tucson, an educational and cultural center of the Southwest, affords access to the community and educational facilities essential to the operation of a major new research facility. The University of Arizona has offered full co-operation in the use of personnel and facilities that may be needed in establishing the new installation.

Kitt Peak is farther south than any of the sites tested, and the southerly latitude has certain advantages because a small additional area of the southern sky can thus be observed. As the astronomers put it, "Every little bit helps."

Navy Vanguard in Orbit 2,513 Miles Up

A 6.4-inch satellite sphere was fired into orbit by U. S. Navy scientists working on the International Geophysical Year (IGY) Project Vanguard.

The three-stage rocket, which is shaped like an elongated rifle shell, was launched on March 17, 1958, at about 7:15 a.m.

Vanguard I, a fragile 72-foot frame, climbed into the clear blue sky, disappearing into the diamond-like brilliance of its trailing flame. The heading was southeast along the Caribbean tracking range, aimed to cross the Equator at an angle of about 32 degrees.

According to astrophysicists at the Cambridge, Mass., Smithsonian Astrophysical Observatory, the tiny "moon" will not be

visible but the casing of the last stage may be seen orbiting just behind the Vanguard I sphere.

The second satellite placed into orbit by the United States is a mere 3¼ pounds. Estimates have put the apogee (the highest point) of its elliptical path around the Earth at 2,513 miles and at its perigee (the lowest point) at 407 miles. These figures far exceed those for any of the other satellites which have been put into orbit either by the U. S. Army or the Soviet Union.

However, the previous orbiting satellites weighed much more—Explorer I, 30.8 pounds; Sputnik I, 184 pounds; and Sputnik II, 1,120 pounds.

The Vanguard I vehicle is simply a test sphere and, as such, it has a minimum of instrumentation. The instrumentation of this unit consists of two radio transmitters. One of these is powered by conventional batteries and the other by solar batteries. These solar batteries draw their power from the sun, and are expected to last a long time.

The earth-circling Vanguard I was tracked by radar so accurate that if it was used in a ball game, it could call a six-inch ball hit out of Yankee Stadium "fair or foul" from a point 88 miles away.

These electronic "eyes" could "see" the rocket long after it had left our atmosphere. Developed for the U. S. Navy Bureau of Aeronautics, these atmosphere-piercing radars were produced by Radio Corporation of America, to provide vital information for successful orbiting of the satellite and to pinpoint the impact areas of the rocket stages.

The demand for such extreme accuracy called for a tower housing these instruments to be protected on all sides by an air-conditioned building, shielding it from winds and sun which could upset micrometer-like calculations. This necessary air-conditioning system was provided by Carrier Corporation for 26 of the 28 tracking stations. It consists of two systems, actually; one to offset the heat generated by the radar and other equipment, and the other to produce exactingly constant temperatures. These units, therefore, are not just for the comfort of the personnel manning the tracking stations.

The Minitrack stations have picked up the radio signals ever since the first report from the San Diego, Calif., station on the first circling of the Earth. Dr. J. P. Hagen, Project Vanguard director, states that preliminary estimates show that the silvery sphere could have a life expectancy of from 5 to 10 years in space.

Technical Apprentice Training Lags in U. S.

The lag in United States apprentice training threatens the nation as seriously as science-education shortcomings. The 260,000 now training are not enough to replace journeymen who will retire or die, much less fill the needs of growing new industries. A University of California study shows that the USSR apprentice program plays a big role in Soviet scientific and technical gains.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Soviet Co-operation

Because of its possible interest to a considerable number of the readers of *Electrical Engineering*, the following letter—received by J. G. Truxal (M '54), vice-chairman, AIEE Feedback Control Systems Committee—has been translated for publication.

Academy of Sciences for the Union of USSR

National Committee of the Soviet Union on Automatic Control

February 10, 1958

Deeply respected Prof. Truxal:

The National Committee of the Soviet Union on Automatic Control sends you its greetings in connection with the conclusion of the agreement between the USA and the USSR on scientific and technical and cultural relations. We believe that this will contribute to strengthening and further development of scientific ties between the scientists of the USA and the USSR in the interest of peace in the whole world. Please give my warm regards to your colleagues working in the field of automatic control in connection with the conclusion of the above mentioned agreement.

(signed) V. A. TRAPEZNIKOV

(Chairman of the National Committee of the USSR on Automatic Control)

Technical and Scientific Center

Reprinted below is the proclamation adopted by the San Diego (Calif.) Industrial Development Council Inc.

Resolution
February 7, 1958

WHEREAS, one of the most important factors in defense is in decreasing the length of time it takes to engineer and test a project before it gets into production stage or in decreasing the production lead time and many of the most important scientific discoveries are actually rediscoveries, and

WHEREAS, present day methods of automation has provided us with means whereby the use of the Charactron tube, and data processing and recording equipment may be used to scan automatically, record and translate technical and scientific information previously performed for related problems as well as automatic language translation, that may be instantly used for reference material on a problem, and

WHEREAS, at present it is extremely difficult for one industry to receive information on an identical problem that another has encountered or the same could apply to each branch of the armed services, and

WHEREAS, since the majority of the research for missile and space projects is being conducted in the western part of the United States, and

WHEREAS, the North Island Post 758 of the American Legion has adopted a resolution calling for a Technical and Scientific Information Center to be set up to provide for solution of engineering problems and that this Information Center be directed by the newly appointed Cabinet Officer, Dr. James R. Killian, and to be provided with the most modern automatic data scanning and recording equipment to provide immediate reference information to all industries working on related projects for the armed services, therefore

BE IT RESOLVED that the San Diego Industrial Development Council Inc. go on record as endorsing said resolution of the American Legion, and

BE IT FURTHER RESOLVED that the Technical Information Center be located in San Diego, California, and that this resolution be forwarded to the proper authorities for immediate action.

Submitted,

(signed) ROBERT J. MC PHERSON

(Past President)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AUTOMATION AND MANAGEMENT. By J. R. Bright. Harvard University, Graduate School of Business Administration, Boston, Mass., 1958. 270 pages, 8¾ by 11¼ inches, bound. $10. Three major aspects of automation are studied extensively in this report. The first section provides a background on the nature of production line mechanization and the growth of automaticity in manufacturing; the second describes the automation programs of 13 plants with respect to conception, design, procurement, installation, and debugging experiences; and the final section discusses the impact of automation on maintenance, the skill requirements of the work force, and management.

BASIC ELECTRICAL ENGINEERING. By R. H. Nau. Ronald Press Company, 15 E. 26th St., New York 10, N.Y., 1958. 437 pages, 6¼ by 9¼ inches, bound. $7. Both a-c and d-c circuits are presented. Basic network considerations are developed and a treatment of node-voltage and mesh-current methods is given. The material on magnetism and magnetic circuits includes concepts of domain theory. A final chapter explains the theory and operation of modern electrical instruments and meters. The rationalized MKS (meter-kilogram-second) system of units is used.

CONDUCTIVE RUBBER. By R. H. Norman. Maclaren and Sons, Ltd., London, England, 1957. 99 pages, 7½ by 10 inches, bound. $3. Rubbers made conductive by the presence of

carbon blacks are studied in this monograph from the standpoint of contact resistance; manufacture; effects of stress, time, and other variables on resistivity; test methods; and variability of resistivity. The uses of conductive rubber in the dissipation of electrostatic charges in heating applications, and in cables are outlined and relevant data provided.

DISLOCATIONS AND MECHANICAL PROPERTIES OF CRYSTALS. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 634 pages, 6 by 9¼ inches, bound. $15. The proceedings of an international conference at Lake Placid, September 1956, this book constitutes a review of the principal methods for observing individual dislocations. The papers presented are grouped within the following major categories: direct observation of dislocations; deformation of pure single crystals; work hardening and recovery; alloy crystals, impurities, and yield point phenomena; dislocation damping and fatigue; theory of dislocations; whiskers and thin crystals; and radiation damage. Discussions relative to individual papers are included.

ELECTRIC CONTACTS HANDBOOK. By Ragnar Holm. Springer-Verlag, Berlin, Germany, third edition, 1958. 522 pages, 6¼ by 9¼ inches, bound. DM 52.50. A thorough study of contacts and their applications presented in four parts: (1) stationary contacts; (2) sliding contacts, including several chapters on friction and wear; (3) electric phenomena in switching contacts; and (4) a historical survey of the field. Appendixes give related information on the tunnel effect, the theory of the arc, the structure of carbon, and the band theory of electric conduction in solids. Because many of the concepts of contact phenomena have been developed recently, the author attempts to bring out the limits of validity of important statements.

ELECTRICAL DISCHARGES IN GASES. By F. M. Penning. Philips Technical Library, Eindhoven, Holland; Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1957. 75 pages, 6¼ by 9¼ inches, bound. $3. A series of essays on a variety of aspects of the subject including studies on the movement of electrons and ions through a gas, the nonself-sustaining arc discharge, the Townshend discharge and breakdown, sparks and lighting, the glow discharge, the self-sustaining arc discharge, and the positive column.

ELECTRICAL REFRESHER. By J. D. Constance Published by the author, 625 Hudson Terrace, Cliffside Park, N.J., third edition, 1958. Various pagings, 11 by 8½ inches, paper. $3. Primarily intended as a review for professional engineering examinations, this volume is also useful for reference purposes. Subject matter includes: d-c circuits and machinery; power, energy, and thermal units; units of area and resistance: d-c transmission; magnets and magnetic circuits; and a-c circuits and machinery. Illustrative problems are liberally included, with the practical aspects of each problem reviewed and the necessary formulas given. Solutions are worked out mathematically.

INSTRUMENTATION IN TESTING AIRCRAFT. By C. N. Jaques. Chapman & Hall, Ltd., London, England, 1957. 291 pages, 5½ by 8¾ inches, bound. 45s. Examines the development and application of special instruments used to determine aerodynamic, structural, and aero-engine characteristics. The subject is presented in three major divisions: (1) basic principles; (2) measurement of physical quantities; and (3) data transmission and recording, including recording methods, continuous trace recording equipment, and intermittent recording equipment. Little reference is made to American equipment, and, for the most part, the discussion is restricted to British practice.

INTRODUCTION AU GÉNIE NUCLÉAIRE. Volume 1, 388 pages, Physique et Calcul des Réacteurs Nucléaires; Volume 2, 396 pages, Contrôle et Protection des Réacteurs Nucléaires. By Théo Kahan and Maurice Gauzit. Dunod, Paris, France, 1957. 6¼ by 9¼ inches, bound. 5,900 fr. each. Volume I of this two-volume set covers the fundamentals of nuclear physics, the basic theory of nuclear reactors, and the design and calculations of several types of reactors including a brief discussion of one Soviet installation. Volume II deals with reactor control, and with the detection of radiation, radiation danger, and protection. A brief treatment of the liberation of energy from the fusion of light elements is appended.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to: R. H. Phelps, Director, Engineering Societies Library, 29 W 39 St. New York 18, N. Y.

KEMPE'S ENGINEER'S YEARBOOK. Morgan Brothers, Ltd., London, England, sixty-third edition, 1958. 2 volumes, 4¼ by 7 inches, bound. 82s6d. A new edition of a handbook covering virtually all fields of engineering. Although all sections have been rewritten to some extent, the following areas have been extensively revised: welding and cutting; water engineering; corrosion and protective coatings; blasting processes and new abrasive materials; aerodynamics and aircraft propulsion; electronic engineering; atomic power; and heating, ventilating, and air conditioning.

LIVING WITH THE SUN, VOLUME I. Published by the Association for Applied Solar Energy, 2424 North Central Ave., Phoenix, Ariz., 1958. 12 pages, 60 plans, 14¼ by 14¼ inches, spiral binding. $6. Plans selected from 60 entries in the 1957 international architectural competition to design a solar-heated residence. Two principal solutions to the design of solar energy units are utilized. In the first, the solar collectors are assumed to be an integral part of the house, whereas in the second, the heat-collecting mechanism is kept as a separate entity. Design notes offer an explanation of the design and proposed method of operation, with an indication of the estimated heat loss and gain.

NATIONAL SYMPOSIUM ON VACUUM TECHNOLOGY TRANSACTIONS, 1956. Published for the Committee on Vacuum Techniques by Pergamon Press, 122 E. 55th St., New York 22, N.Y., 1957. 234 pages, 8½ by 11 inches, bound. $12.50. Current developments in vacuum techniques are presented in the following areas: fundamental developments in vacuum technology; methods and techniques for obtaining higher vacuum; instrumentation, controls, and other vacuum devices; vacuum distillation; metallurgical and chemical applications; and technical subjects of related interest A useful feature is the glossary of terms used in vacuum technology.

NUCLEAR MASSES AND THEIR DETERMINATION. Edited by H. Hintenberger. Pergamon Press, 122 E. 55th St., New York 22, N.Y., 1957. 267 pages, 5¾ by 8¼ inches, bound. $14. Papers presented at a conference held in the Max-Planck-Institut für Chemie, 1956. Devoted to the precision determination of atomic nuclear masses, the papers encompass the following areas: atomic masses and nuclear structure, mass-spectroscopic results, nuclear masses from nuclear reactions, comparison between nuclear masses from Q-values and mass-spectroscopic doublets, atomic masses from nuclear wave spectra, and instruments. A discussion on the papers is included.

PHYSIK UND TECHNIK DER ATOMREAKTOREN. By Ferdinand Cap. Springer-Verlag, Vienna, Austria, 1957. 487 pages, 6¼ by 10 inches, bound. $15.25. A comprehensive treatment of the physics and technology of nuclear reactors. The author provides a thorough review of the present state of knowledge and discusses the theory, construction, characteristics, operation, and application of reactors. All aspects receive detailed physical and mathematical considerâtion. Literature references, information sources, and a list of present and projected reactors are included.

PRODUCTION PLANNING AND INVENTORY CONTROL. By J. F. Magee. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 333 pages, 6¼ by 9¼ inches, bound. $7.50. Covering the field from the viewpoint of operations research thinking, preliminary chapters outline the functions of inventories and planning and of the policies and costs bearing on them. The latter portion of the volume deals with the design of planning and control systems. Specific applications include the use of servo theory concepts to control production fluctuations, linear programming in seasonal planning, new scheduling devices, methods for very short-run forecasting, and the basic stock concept for controlling production and distribution through several stages.

LA PROPULSION PAR FUSÉES. By Marcel Barrère and others. Dunod, Paris, France, 1957. 389 pages, 6¼ by 9¼ inches, paper. 5,600 fr. A thorough treatment of the theory and practice of rocket propulsion. The beginning chapters deal with the general aspects of energy production, propulsion tube theory, and the characteristics of rocket motors. The characteristics, manipulation, and combustion of both solid and liquid propellants are considered in detail, including the fuel sytems. Both low and high frequency instability of combustion are treated, and the last three chapters are devoted to the exterior ballistics of rockets.

SATELLITES AND SPACEFLIGHT. By Eric Burgess. The Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1957. 159 pages, 5¾ by 8½ inches, bound. $3.95. The development of the earth satellite is presented with details on construction, instrumentation, launching procedure, transmission of data, and flight orbit. This is followed by a consideration of the spaceflight program and the physiological and psychological problems connected with manned rockets and the establishment of a manned station in space. The concluding portion of the book examines the possibility of expeditions to the moon and the planets.

SYMPOSIUM ON THERMAL CONDUCTIVITY MEASUREMENTS AND APPLICATIONS OF THERMAL INSULATIONS. Published as Special Technical Publication No. 217 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1957. 86 pages, 6¼ by 9¼ inches, bound. $2.75. Six papers dealing with the development of specifications and methods of test for thermal insulating materials. Aspects included are analyses and experimental procedures by which criteria may be developed, improvements and modifications of the apparatus within the scope of the test method, the effect of moisture on thermal insulation, and the use of thermal insulation for underground piping

THE ULTRAHIGH-FREQUENCY PERFORMANCE OF RECEIVING TUBES. By W. E. Benham and I. A. Harris. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 173 pages, 5¾ by 8¼ inches, bound. $6.50. Presents the theory of the conventional tube as a circuit element, enabling linear circuit analysis to be applied to the problem of tube amplifiers for small signals at ultrahigh-frequencies. In addition, a detailed account of the electronic processes in a tube is presented as an introduction to the transit time theory of thermionic devices. A mathematical basis for studying problems within the framework of this theory is provided.

VACUUM MELTING. Published by Vacuum Melting, 1383 Panther Rd., Rydal, Pa., 1957. 136 pages, 8½ by 11 inches, spiral binding. $7.50. This book was originally prepared by a group of students in the Graduate School of Business Administration of Harvard University. The report, dealing with an increasingly important aspect of metallurgy, begins with a historical background, followed by a description of various melting processes including induction vacuum, vacuum arc, resistance, zone, and levitation melting. The properties and uses of vacuum melted metals are analyzed and a selector chart is provided indicating applications, sources, and methods of production. An economic study of the industry concludes the report.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

HEATING VENTILATING AIR CONDITIONING GUIDE 1958, 36th Edition. The largest annual edition published by the American Society of Heating and Air-Conditioning Engineers (ASHAE), this reference work contains a greatly expanded Technical Data Section. The Catalog Data Section follows the pattern of other editions, but the equipment data have been brought up to date. The pages contain both descriptive and performance information as well as application data. The general format of the text is in seven sections: fundamentals, human reactions, heating and cooling loads, combustion and consumption of fuels, systems and equipment, special systems, and instruments and codes. For convenient reference both the Technical and Catalog Data Sections are indexed throughout. The ASHAE Psychrometric Chart is included in a pocket in the back cover. Priced at $12, the Guide may be obtained from ASHAE, 62 Worth St., New York 13, N. Y.

EIA STANDARDS. The Electronic Industries Association (EIA, formerly RETMA) recently issued six new recommended standards for the electronics industry. The standards were published following approval by representatives of the industry, including members and nonmembers of EIA. Available through the EIA Engineering Department, 11 W. 42nd St., New York 36, N. Y., the new standards are: *RS-200* "Circular Waveguides," 30¢; *RS-203* "Microwave Transmission Systems," $1.30; *RS-204* Minimum Standards for Land-Mobile Communications, FM or PM Receivers," 90¢; *RS-205* "Electrolytic Capacitors for Use Primarily in Transmitters and Electronic Instruments," 80¢; *RS-206* "Recommended Practice for Preparation of Basing or Terminal Diagrams," 60¢; and *RS-208* "Definition and Register, Printed Wiring," 25¢. (A minimum charge of $1 is made on all orders.)

FOUR CATALOGS OF TECHNICAL REPORTS. Published by the Office of Technical Services (OTS), U. S. Department of Commerce, these catalogs list all research reports available from the OTS collection in the fields of printed electronic circuits, electronic miniaturization, paper capacitors, and transformers. Many of the reports listed in the catalogs are the result of research conducted for the U. S. Army, Navy, Air Force, and other agencies of the U. S. Government. Others are German documents captured by the Allies during World War II. All reports listed are for sale to the public, some in printed form from OTS and others in microfilm or photocopy from the Library of Congress. The catalogs may be ordered from OTS, U. S. Department of Commerce, Washington 25, at 10¢ each. They are: *CTR-249* "Printed Electronic Circuits," 1947-58; *CTR-250* "Electronic Miniaturization," 1944-58; *CTR-99* "Paper Capacitors," 1937-57; and *CTR-336* "Transformers," 1927-58.

QUEUES, INVENTORIES, AND MAINTENANCE. By P. M. Morse, this is the first in a new series entitled "Publications in Operations Research," sponsored by the Operations Research Society of America and John Wiley & Sons. Subtitled "The Analysis of Operational Systems with Variable Demand and Supply," the new volume provides a general description of the subject, defines terms, and outlines some of the analytic aspects of the theory. Dr. Morse deals with the queuing problem from the standpoint of the Kolmogorov equations relating the probabilities, supplies a unified method for expressing various problems in terms of difference equations, and then gives various procedures for solving these equations. A unified discussion of effect of changes of arrival and service distributions on queuing results is given. The book contains 202 pages and may be ordered from John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $6.50.

TELEVISION FACTBOOK. This 488-page publication gives information about every station on the air, but is largely devoted to detailed data on stations in the U. S. and Canada, including digests of their commercial rate cards. In addition to station directories, the factbook contains more than 50 reference departments, such as directories of television and radio set manufacturers, attorneys and consulting engineers, and associations dealing with television. It also carries complete statistical tables on television time sales and set and tube production, as well as the names of high fidelity equipment, phonograph, and transistor manufacturers, plus new statistics on the electronic industry from 1914. It may be ordered at $5 from Television Digest, Wyatt Bldg., Washington, D. C.

TOPOLOGICAL FORMULAS FOR NETWORK FUNCTIONS. By Wataru Mayeda and Sundaram Seshu, this is the report of an investigation conducted by the Engineering Experiment Station of the University of Illinois in co-operation with the Office of Ordnance Research, Department of the Army. The objectives of the report were to give a unified and fairly complete picture of the subject which could be read without referring extensively to other papers, to present formal and precise proofs of a number of topological formulas, and to present a number of new topological formulas for the open and short circuit functions and current and voltage ratio transfer functions of two terminal-pair networks. The current interest in topological formulas has developed because of the possibilities they present in discovering radically new synthesis procedures for lumped networks (which can be extended to cover all lumped systems). The report, Bulletin No. 446, may be ordered from the University of Illinois, Office of Publication, 207 Administration Bldg., Urbana, Ill. Price $1.

TELEMETRY STANDARDS FOR GUIDED MISSILES. The Inter-Range Instrumentation Group (IRIG) Steering Committee, representing the major Department of Defense missile test ranges, has assigned the task of promulgating new or revised telemetry standards to the Inter-Range Telemetry Working Group (IRTWG). These standards have been issued to further compatibility of airborne transmitting equipments and ground receiving and data handling equipments at missile test ranges. To this end, it is the recommendation of the IRIG Steering Committee that telemetry equipment at the test ranges conform to these standards. It is expected that these standards will be revised from time to time as the need arises. The standards are prepared in terms of the characteristics of the signals to be transmitted by the data links, rather than by specifying terminal equipment characteristics, in order to permit flexibility in the choice of transmitting and receiving equipment components. Copies of this document, No. 103-56, may be obtained from the IRIG Secretariat, White Sands Proving Ground, New Mexico. Also available is Document No. 101-57, Magnetic Recorder/Reproducer Standards.

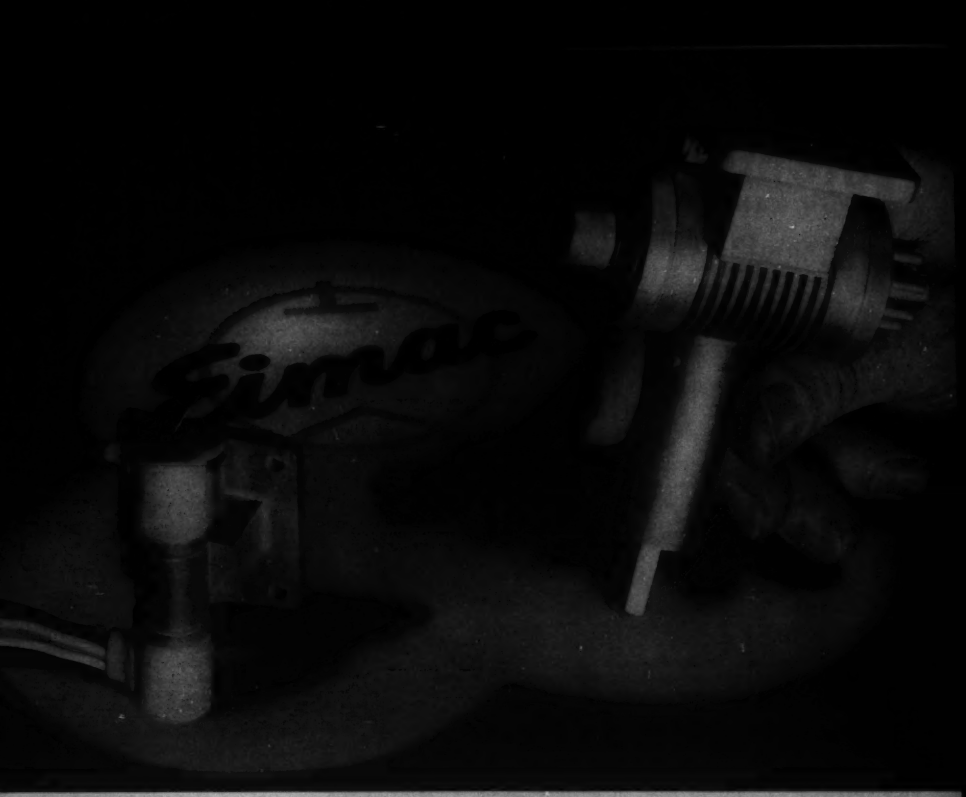
PROGRESS IN PEACEFUL USES OF ATOMIC ENERGY, July–December 1957. This report by the United States Atomic Energy Commission discusses the gains made in the field of atomic energy for peaceful purposes. Chapter I contains a three-year survey of U. S. atomic achievements for peaceful uses and the Commission's contributions to those gains; Chapter II describes progress with radioisotopes; Chapter III, progress with power reactors; Chapter IV, growth of the atomic energy industry; Chapter V, progress in international cooperation; and Chapter VI, progress with physical research. The second section of the report deals with major activities in selected atomic energy programs. The 14 appendixes include a listing of nuclear reactors built, building, or planned in the U. S. as of Dec. 31, 1957, and a statement on radioactive fallout by the Advisory Committee on Biology and Medicine. The report is available at $1.25 from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

STUDY AND DEVELOPMENT OF MAGNETIC AMPLIFIER CONTROLLED SERVO SYSTEMS. Development of techniques for applying magnetic amplifiers to servo systems is described in this five-volume report. The research was aimed at determining what magnetic amplifiers are applicable to servomechanisms and then establishing criteria for co-ordinated design of amplifiers and servo motors. Sponsored by the U. S. Air Force, the report was prepared by Yale University and may be ordered from the Office of Technical Services (OTS), U.S. Department of Commerce, Washington 25, D. C. The five parts are: *PB 131203*, Part 1: The Theory of Control of Magnetic Amplifiers, R. C. Barker, June 1955, 191 pages, $5; *PB 131209*, Part 2: Superimposed Magnetization in Materials with Rectangular Hysteresis Loops, C. B. Wakeman, June 1955, 122 pages, $3.25; *PB 131215*, Part 3: The Coordinated Design of Magnetic Amplifiers and Motors, A. R. Perrins, May 1956, 107 pages, $2.75; *PB 131236*, Part 4: Diverse Topics: Magnetic Frequency Multipliers, Two Phase Servo, Relay Servo, Input Circuits, Coupling Networks, R. C. Barker, C. B. Wakeman, and A. R. Perrins, Sept. 1956, 154 pages, $4; and *PB 131251*, Part 5: Summary and Recommendations, R. C. Barker, Dec. 1956, 105 pages, $2.75.

METHODS OF TESTING THERMOCOUPLES AND THERMOCOUPLE MATERIALS. By W. R. Reser and S. T. Lonberger, this publication describes methods of testing thermocouples and thermocouple materials, pointing out precautions that must be observed to obtain reliable results. The circular considers calibration of platinum vs. platinum-rhodium, copper-constantan, Chromel-Alumel, and iron-constantan thermocouples; calibration at freezing points, melting points, and boiling points; and calibration by comparison methods. The accuracies obtained in calibrating the various types of thermocouples by different methods, and the uncertainty in the interpolated values by various methods are presented in a table. Circular 590, National Bureau of Standards Circular 590, 21 pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. at 20¢. (Foreign remittances must be in U. S. exchange and should include an additional one fourth of the publication price to cover mailing costs.)

HIGH-SPEED PHOTOGRAPHY, VOLUME 6. This latest volume of the Society of Motion Picture and Television Engineers' (SMPTE) reprint series begins with a description of a tracking telescope type of optical recording instrument for missile programs at White Sands Proving Ground. Other articles discuss photography and equipment for guided missile research, light sources, electronic timing devices, special films, and methods for analysis for high-speed data. Two papers from the Naval School of Medicine and Dentistry describe developments of 16-mm projectors for research films. A color schlieren system for high-speed photography is illustrated in color. The volume ends with an eight page cumulative index of the contents of all six books in the series (120 papers). These SMPTE reprint volumes are comprised of papers which have appeared in the Society's *Journal*, with current volumes containing papers collected since Volume 5 was published in 1954. Volumes 4 and 5 of the series are still available. Volume 6, containing 200 pages (27 articles and index), is priced at $3.50. All three may be ordered from SMPTE, 55 W. 42nd St., New York 36, N. Y.

LIBRARY OF CONGRESS MONTHLY PUBLICATIONS. The names of two Library of Congress monthly publications, which serve as keys to new literature coming into the United States from the USSR and East Europe, will be changed from "Lists" to "Indexes." The purpose of the change is to emphasize their thorough indexing in English. Both "Monthly Index of Russian Accessions" and "East European Accessions Index" give in English a monthly account of new material in a variety of subject fields as received by the Library of Congress and other American research libraries. The translation of all titles of books and articles into English, and the elaborate subject guides, permit a researcher to identify easily the material important to him. The indexes are of particular interest to the scientist inasmuch as the bulk of the articles reported are in the field of science and technology. The "Monthly Index of Russian Accessions" is priced at $12 a year ($15 abroad), the "East European Accessions Index" at $10 a year ($12.50 abroad). Both are available from the Government Printing Office, Washington 25, D. C.



1K20 Series X and K Band Klystron (left)
1K125CA C Band Klystron (righ

Eimac Announces...

Five New Ceramic Reflex Klystrons

Two important frequency ranges in the C, X and K bands are now covered by Eimac reflex klystrons. Eimac's advanced stacked ceramic design gives these tubes exceptional ruggedness and frequency stability.

The four new tubes of the 1K20 series cover 8500 to 11,700 Mc., at power levels up to 50 milliwatts. They are specifically designed for use in the severe environment of air-borne and missile radar systems. They will withstand vibration levels of 15G in any reference plane, with less than 100 kilocycle frequency deviation. Low beam voltage requirement and simple radiation cooling minimize the weight and complexity of associated equipment.

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Eimac know-how in the field of ceramic-metal tube design now brings compactness, ruggedness, high performance and reliability to these important microwave frequencies.

More information on Eimac reflex klystrons is available from our Application Engineering Department

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GENERAL CHARACTERISTICS

Type	Freq. Range Mc.	Beam Voltage	Power Output Range	Reflector Voltage
1K125CA	3700-4400	1000 Vdc	1.5 to 2.0 W	0 to —1000 Vdc
1K20XS	8500-9300	300 Vdc	25 to 50 mW	0 to —250 Vdc
1K20XK	9200-10,000	300 Vdc	25 to 50 mW	0 to —250 Vdc
1K20XD	10,000-10,800	300 Vdc	25 to 50 mW	0 to —250 Vdc
1K20KA	10,700-11,700	300 Vdc	25 to 50 mW	0 to —250 Vdc

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Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

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The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

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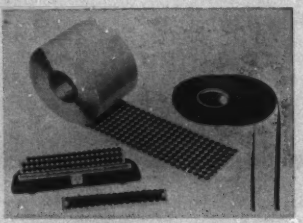
Circle 14 on the card.

NEW PRODUCTS

Density Measurement System. An Accu-Ray density system which measures and/or controls fluid density, specific gravity, per cent solids, or related quantity has been announced by Industrial Nucleonics Corporation, 1205 Chesapeake Ave., Columbus, Ohio. This new density unit is applicable to liquids, slurries, and flaked, granulated, powdered, or other divided solids. Based on the principles of gamma ray transmission from a radioisotope, the system makes no physical contact with the flowing material. Measurements are also independent of flow rate and pressure. *Circle 201 on the card.*

Fast-to-Apply Precut Selfadhesive Felt. Selfadhesive felt, precut in a wide variety of shapes and sizes is now available. Mounted on special fast-to-dispense Blue Streak (registered trade mark) cards or liners, the new product, called "Quik-Felt" can be used for sealing, cushioning, spacing, insulating, and protecting parts in maintenance and production work. Mere finger pressure assures adhesion to glass,



ceramic, wood, metal, and plastics. Free usable samples, prices, and Bulletin No. *187* sent on request. Write W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis. *Circle 202 on the card.*

Improved Constant Wattage Mercury Transformer. A weatherproof-watertight constant wattage mercury lamp transformer for one *H-1* 400-watt mercury lamp has been made available by Sola Electric Company. The transformer's lamp current crest factor (peak/rms ratio) is less than 1.7, the manufacturer reports and states this low-crest factor provides additionally extended lamp life, and excellent lumen maintenance with lamps mounted in either a horizontal or vertical position. Open circuit voltage over the entire range is 300 volts minimum. Positive starting is assured down to —30F. The constant wattage circuit provides constant wattage regulation of ±1% with line voltage swings as large as ±13%. The new transformer is 20% lighter and 25% smaller than previous models, to make handling and installation easier. Further information is available by writing Sola Electric Company, 4633 W. 16th St., Chicago 50, Ill. *Circle 203 on the card.*

Carrier Preamplifier. This carrier preamplifier with integral power supply is a selfcontained unit designed to drive optical recording systems, tape recorders, oscilloscopes, panel meters, etc. The Sanborn Model *450-1100* carrier preamplifier, second of the new *450* series instruments, features high performance, versatile use, and flexibility that permits packaging in either a portable case or in 4-unit modules for standard rack mounting. Complete data is available on request from the manufacturer, Sanborn Company, Industrial Division, 175 Wyman St., Waltham 54, Mass. *Circle 204 on the card.*

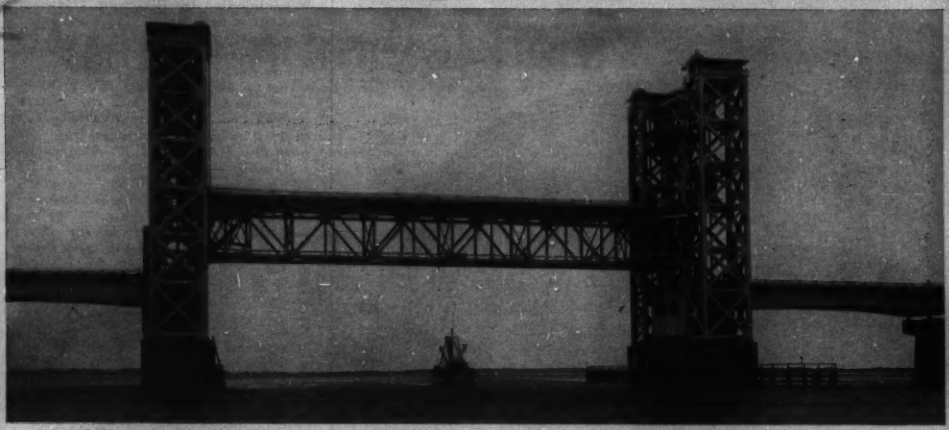
Transistorized Voltage Regulated Power Supply. Release of a tubeless transistorized voltage regulated power supply featuring excellent regulation, low ripple content, fast recovery time, good stability, and low output impedance has been announced. The Model *SC-32-1.5* delivers 0-32 volts, 0-1.5 amperes. Regulation for line or load is less than 0.03% or 0.003 volts, whichever is greater. Ripple is less than 3 millivolts rms. Recovery time is less than 50 microseconds. Stability for eight hours is less than 0.03% or 0.003 volts, whichever is greater. Output impedance is less than 0.01 ohms. For further information contact Kepco Laboratories, Inc., 131-38 Sanford Ave., Flushing 55, N. Y. *Circle 205 on the card.*

Sellevision. In its unusual Sellevision system, The Siegler Corporation's Hallamore Electronics Co. Division, Anaheim, Calif., presents a completely new method of communication employing a proved medium, filmed programming. The Sellevision unit, consisting of a steel console standing 6 feet high, continuously projects slide or moving picture images onto an integral screen at eye-level. Sharply detailed pictures in color or black-and-white are transmitted from a self-contained projector by way of three high-reflection mirrors to a screen not measurably affected by room illumination. Sellevision has applications wherever people congregate in small groups, including depots, airports, offices, industrial plants, hotel lobbies, trade and home shows, and dealer showrooms. The motion picture version is known as Sellevision Model *M* and the slide version is Model *S*. *Circle 206 on the card.*

Milipots. These multiturn precision wire wound potentiometers, 1 inch diameter by 1.8 inch long, are popular priced units featuring all metal cases. Other features include dual terminals riveted to terminal board, terminals independent of resistance element terminations, extremely low end resistances to 0.01% of total resistance, standard screw-driver slotted stainless steel shafts, permanently lubricated bearings, precious metal brushes and slip rings, and elimination of both "O" rings and shaft end-thrust on rear cover. Also available with plain phenolic case. Write Alfred Voak, Voak Engineering Co., 129 East "A" St., Upland, Calif., for additional information. *Circle 207 on the card.*

(Continued on page 22A)

bring the big ones to life



A 250-foot lift span, weighing well over one thousand tons, is raised by Okocord power and control cables to pass a shrimp boat under the new Sidney Lanier Bridge across Turtle River in Brunswick, Georgia. Designers, Sverdrup & Parcel; J. E. Greiner Co. and Associates, consultants; Georgia State Highway Department, supervisory engineers; electrical contractors, Harrison's Service of Brunswick. The unusual lifting mechanism is wired with more than ¾ of a mile of tough, flexible Okocord cables.

Why Okocord was picked

After various designs and estimates had been submitted, the Okocord constructions recommended by Okonite engineers got the nod. Interesting features of these cables were the steel rope core for reinforcing the multi-conductor control cable and the high moisture resistance of Okonite's insulation. Also, Okonite was able to point to at least two other Okocord installations in which similar conditions of environment, tension and mechanical action had been successfully met.

Installed more than a year ago, these Okocord cables have successfully brought the big Sidney Lanier Bridge to life. And engineers estimate that service life will at least equal a far more expensive submarine installation.

If your operation involves portable or flexible cable, write for Bulletin EG-1108 and find out how rugged, dependable Okocord can save time, replacement costs and down time losses. In fact, whatever your cable needs, when you talk to Okonite, you get unprejudiced recommendations, because Okonite, and *only* Okonite, makes cable by all four insulating methods: strip, dip, extrusion and taping. The Okonite Company, Passaic, New Jersey.

Vital links that control and power the bridge's motors, lights, alarms and gates are these three Okocord cables. Two lengths of each are used on either end of the span. Left to right are the 45-conductor, steel rope core cable for the intricate control system; the 6-conductor cable that powers the main drive motors; the 12-conductor, steel rope core cable that controls and powers the auxiliary drive motors. Each cable is protected against constant bending as well as environmental conditions by a tough, reinforced wall of mold-cured Okoprene.

***where there's electrical power . . . there's* OKONITE CABLE**

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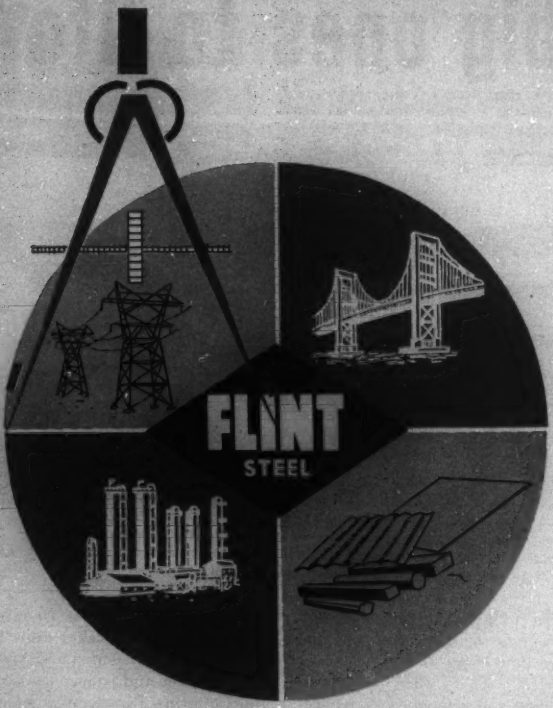

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are inter-related and singly managed.

Flint invites you to investigate the possibility of using these facilities to your advantage.

for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

For more information circle 17 on reader service card.

New Products

(Continued from page 18A)

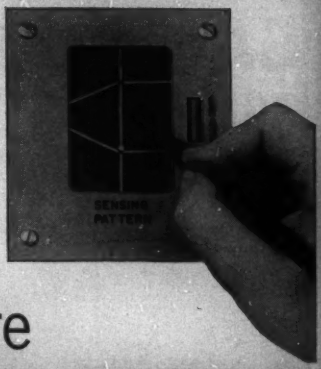
Signal-Injection Direct-Viewing Television Analyst. A new Model *1075* signal-injection direct-viewing television analyst for quick, direct, complete television trouble-shooting is announced by B&K Manufacturing Co. With the Model *1075*, point-to-point signal injection and test pattern reproduction, any service technician can easily trouble-shoot and signal-trace any stage throughout the r-f, i-f, video, audio, and sweep sections of black and white and color receivers. It quickly isolates and diagnoses television troubles, including intermittents. By use of the generated test pattern, you can actually see the condition directly on the picture tube screen of the television set itself. No external scope is needed. The Model *1075* television analyst is practically a complete service shop in one instrument. For further information, write for Bulletin *TAD-18* to B&K Manufacturing Co., 3726 N. Southport Ave., Chicago 13, Ill. *Circle 208 on the card.*

High-Power Frequency Converters. A new line of high-power frequency converters has been put on the market. They are applicable wherever a variable frequency power source is required having extremely low source impedance and distortion. The new TIC Model *411*, *421*, and *431* frequency converters are particularly useful in conjunction with magnetic amplifiers, servo systems, aircraft instruments, and other equipment requiring 330 to 3,700 cycles per second power. For complete technical data write to Tel-Instrument Electronics Corp., Dept. F, 728 Garden St., Carlstadt, N. J. *Circle 209 on the card.*

D-C Spindle Motor. A series of three-dimensional profile milling machines with d-c spindle motors, power unit, and control, has been announced by Ekstrom-Carlson's Rockford, Ill., plant. Allis-Chalmers Manufacturing Company, Box 512, Milwaukee 1, Wis., developed this 50 to 6,000 rpm motor, in the shell type with electronic power unit and control, to meet requirements established by Ekstrom-Carlson engineers. The new motor is the first d-c motor of shell type design. The variable speed of the d-c motor permits machining of various metals, each at a speed that is optimum for maximum work production and cutter life. The motor is rated 10 hp, intermittent service at a base speed of 1,500 rpm. The motor delivers constant torque from 50 rpm to 1,500 rpm and constant horsepower from 1,500 rpm to 6,000 rpm. Variation of armature voltage causes speed variation in the range below base speed. Adjustment of motor field voltage permits speed variation in the range above base speed. Other sizes and ratings of this type of motor will be produced as required. Also available from Allis-Chalmers is a wide range of air-cooled, open, and enclosed motors of conventional and special designs. *Circle 210 on the card.*

(Continued on page 28A)

Write a numeral here



and read it here

on new Bell Labs machine

A new device invented at Bell Laboratories "reads" a numeral while it is being written and instantly converts it into distinctive electric signals. The signals may be employed to make a numeral light up in a display panel, as above, or they may be sent to a computer or to a magnetic "memory" for storage.

The writing is done with a metal stylus on a specially prepared surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from the dots. Transistorized logic circuits recognize numerals according to which lines are crossed.

The concept of a number-reader has interesting possibilities as a new means of communication from humans to machines. For example, in an adjunct to a telephone, it might provide inexpensive means of converting handwritten data into signals which machines can read. The signals could be transmitted through the regular telephone network to a teletypewriter or computer at a distant point. In this way, a salesman might quickly and easily furnish sales data to headquarters, or a merchant might order goods from a warehouse.

Tom Dimond, a B.S. in E.E. from the University of Iowa, demonstrates an experimental model of his number-reading invention. A similar device can also be made to read alphabetical characters. Small size and low power requirements result from transistor circuitry.

Modern communication involves many more fields of inquiry than the transmission and reception of sound. The experimental number-reader is but one example of Bell Telephone Laboratories work to improve communications service.

BELL TELEPHONE LABORATORIES
World Center of Communications Research and Development

For more information circle 21 on reader service card.

GAI-TRONICS
COMMUNICATIONS
WERE SELECTED FOR...
Shippingport
At the first full-scale, atomic-electric power plant devoted exclusively to serve civilian needs, Duquesne Light Company, builders of the electric generating portion and operators of the entire facility have installed — GAI-TRONICS communication equipment.
Throughout the world, wherever a highly dependable, voice communication system for use in high noise level areas is needed — you'll find GAI-TRONICS specified by name.
GAI-TRONICS
Dept. B
GAI
A SUBSIDIARY OF GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
For more information circle 22 on reader service card.

New Products

(Continued from page 22A)

Transducer Element Utilized. A line of ultrasonic processing equipment utilizing a novel, patented transducer element has been introduced. This new transducer element is constructed mainly of solid-metal sections and is joined to stainless steel radiating surfaces by welded studs, resulting in a product which is virtually indestructible. Because of the very high efficiency of this transducer, the equipment is powered by relatively small generators, producing high intensity ultrasonic energy at low initial cost and small operating expense. For further information, contact D. Andrews, General Ultrasonics Company, 67 Mulberry St., Hartford, Conn. *Circle 211 on the card.*

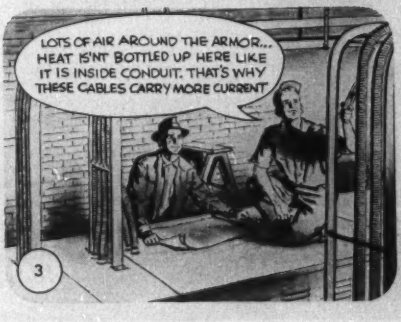
Transmitter Adapter. A compatible single-sideband transmitter adapter has been announced by Kahn Research Laboratories, Inc., 22 Pine St., Freeport, N. Y. This new technique is offered to the radio broadcast and high frequency communications industry as a major state-of-the-art improvement in the transmission of speech and music. The system has been designed to convert any standard high-level, low-level, or Doherty type AM transmitter to a new and improved type of single-sideband operation. Transmitters can be adapted without engineering modifications, and reception is completely compatible on all existing AM receivers. Thus, the following basic advantages over conventional AM methods are available immediately—double to triple effective transmitter power, minimized selective fading distortion, reduced adjacent and co-channel interference, and improved audio fidelity and speech intelligibility. *Circle 212 on the card.*

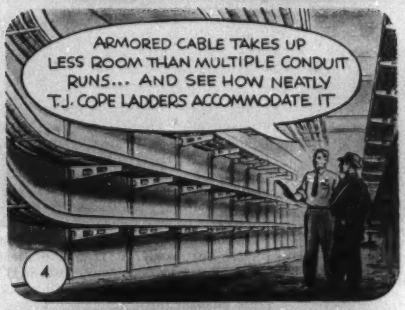
Mechanical Counter. A mechanical counter for instrumentation cameras provides a simple and positive method of correlating events recorded by two or more cameras or other pieces of instrumentation. Costly pulse lighting is not required. The device is available from Traid Corporation, Encino, Calif. Termed the Model 652 correlation counter, the new device is used in photographic instrumentation cameras for missiles and aircraft, as well as for industrial and military laboratory and research evaluations. *Circle 213 on the card.*

Self-contained Ultrasonic Gauge. A complete quality-control installation for ultrasonic thickness gauging, recording, detection of laminar flaws, including connections for automatic sorting and rejection, is now available from Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn. The rack-mounted Model *R Vidigage* (registered trade mark) is comprised of ultrasonic resonance gauging and indicating circuitry, a strip chart recorder, gating and alarm circuits, and calibration control. *Circle 214 on the card.*

(Continued on page 36A)

ROMAN ARMOR'S BEST...

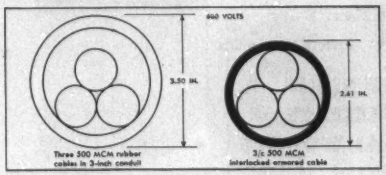

LOTS OF AIR AROUND THE ARMOR... HEAT IS'NT BOTTLED UP HERE LIKE IT IS INSIDE CONDUIT. THAT'S WHY THESE CABLES CARRY MORE CURRENT
3



For 600- to 15,000-volt service Rome's interlocked armored cable is available in three-conductor construction with Rozone A (butyl) insulation. It offers many more benefits than described here. For complete information, contact your nearest Rome Cable representative and ask for your free copy of Bulletin RCP-730. Or mail the coupon today.

ROME CABLE
CORPORATION

A matter of FACT



Reduced space requirements Less space is needed for Rome Cable's interlocked armored cable —almost one inch less width for each three-conductor 500 MCM interlocked cable than for cable-in-conduit type installations.

FREE BULLETIN describes all the benefits of Rome's Interlocked Armored Cable.

ROME CABLE CORPORATION
Department 731, Rome, New York

Please send me a copy of the new Rome Cable Bulletin RCP-730.

Name .....

Title .....

Company .....

Address .....

.....

Type of business .....

MINIATURIZED CARRIER TELEPHONE SYSTEMS FOR RADIO AND 4-WIRE CABLE

FOUR OR 24 CHANNELS

Two miniaturized voice-multiplex systems providing four or 24 voice channels over radio or 4-wire cable are available. They have many advantages over earlier designs: high performance, small size, light weight, low cost, circuit simplicity, low power requirements, small number of tubes of a single type only, low operating cost, low maintenance and high reliability.

These systems provide a voice-channel flat within 1 db from 300 to 3500 cycles, for each 4 kc of bandwidth occupied. Each channel is equipped with hybrid, signalling, and dialling circuits for all the standard 2-wire and 4-wire loop options.

The basic unit provides an order-wire and 4 carrier-derived channels. These units can be stacked in groups of 2, 3, 4 or 5 by means of a group modem to provide 9, 14, 19 or 24 channels. Full flexibility is provided for dropping and inserting channel groups at repeater and terminal points. Moderate lengths of 4-wire cable or open-wire line may be inserted between the multiplex equipment and the radio terminals.

24-channel carrier-telephone terminal complete with hybrids, ringing and dialling circuits, and test facilities. Dimensions are 58" high, 16" wide and 8" deep. Power input 250 watts. Weight 326 lbs.

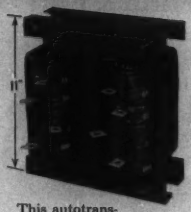
RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE UNiversity 6-6887 CABLES RADENPRO MONTREAL

▲ Circle 28 on the card.

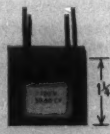
Let Hevi Duty Help You Choose

THE RIGHT SPECIALTY TRANSFORMER

This is just a small sample of the broad line of specialty transformers built by Hevi Duty Electric Company. They are available in all sizes with any desired primary or secondary voltages or frequencies. All are designed to meet or exceed NEMA standards.



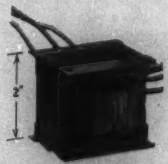
This autotransformer is used for reduced-voltage starting of synchronous and induction motors. 50, 65 and 80 percent taps are normally provided. Terminals may be mounted on the coil or leads.



Low-voltage pilot light transformers up to 600 V primary.

▼ Circle 29 on the card.

Type SICB, 150 VA, 230/460-115 volts, enclosed style with a built-in thermal circuit breaker for overload protection. This compact unit saves valuable panel space.



Type SIO, 10 VA, primary 110/220 volts
CONTROL WINDING — Secondary 230 volts, .032 amps, 7.4 VA
FILAMENT WINDING — Secondary 6.3 volts, .3 amps, 1.9 VA

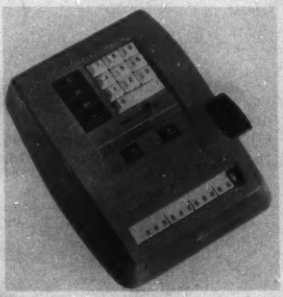
Write for bulletins HD-499 and T-5111 or send us your requirements.

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

New Products

(Continued from page 28A)

Low-Cost 10-Key Calculator. A 10-key personal calculator that adds, subtracts, multiplies and divides, yet weighs only 6 pounds and sells for $125, has been introduced by the Bohn Duplicator Corporation (BDC), 444 Fourth Ave., New York, 16, N. Y. The BDC Contex is manually operated, but has no handle in the ordinary sense. Its actuating bar is similar to the motor bar on electric machines. It is depressed with the palm of the hand,



without removing the fingers from the keyboard. The patented actuating principle that makes this possible also enables the BDC Contex to attain speeds that equal or exceed those of electric machines. Subtotals are shown at every step, and subtraction is direct. The Contex is available through company dealers in over 400 cities. For further information, write to the company. *Circle 215 on the card.*

Snap Action Switches. A line of snap action neutral position switches has been developed. Made in three models. *L100WNS*, *L100WNR*, and *L100WNL*. the switches provide two isolated circuits with double break, four wire, contact arrangements. For a complete description of the new snap action neutral position switches described, write for specification sheet No. *L100WNS*, The R. B. Denison Manufacturing Company, 102 St. Clair Ave., N.W., Cleveland 13, Ohio. *Circle 216 on the card.*

Adjustable Splice Plates. The problem of running aluminum or steel cable support systems over, under, or around obstructions has been made simpler and far less costly with two adjustable splice plates introduced to industry by The Chalfant Products Company, Inc., 11525 Madison Ave., Cleveland 2, Ohio. Both splice plates are engineered so that they easily and quickly slip onto Chalfant cable support systems and securely lock in place without the need for time consuming, on-the-job, field cutting, drilling, or conventional fastener installations. The adjustable splice plates are available in aluminum steel, or in Armco aluminized steel, Type 2. *Circle 217 on the card.*

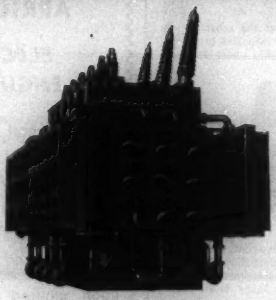
(Continued on page 40A)

harmonic restraint supervising unit to distinguish between inrush and fault currents.

The harmonic differential units will operate in 1.5 to 2.5 cycles; and the instantaneous trip unit will operate in ¾ cycle for heavy internal faults. The relay has low burden, requiring about three volt-amperes at tap value current. Built-in ratio taps compensate for mismatch of line current transformers on both two-and three-winding applications.

Adequate transformer protection is also provided during reduced frequency operation, such as exists during the generator warm-up period.

For further details about HU relay transformer protection, call your Westinghouse sales engineer or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-40504



Type HU relay protects two-winding transformers; HU-1 for use with three-winding transformers.

YOU CAN BE SURE...IF IT'S

Westinghouse

POWER FREQUENCY METERS

...for monitoring of power generating equipment in aircraft, surface vehicles or fixed installations.

MODEL 200 ... designed for continuous indication of frequencies in the 400 cps region

- Accurate to ± 0.25% at 400 cps
- Direct Reading Dial
- Tubeless Circuitry
- Powered by Input Signal
- Ruggedized to MIL-E-5400
- Frequency Range:
  Model 200-D 392-408 cps
  Model 200-E 380-440 cps

May be mounted independently of the sensing mechanism. Tubeless circuits insure long, trouble-free life under extreme conditions.

MODEL 292 ... designed for continuous indication in the 400 cps region where calibration accuracies of ± 0.1% are required.

- Calibration Accuracy ± 0.1%
- Direct Reading Dial
- Tuning Fork Calibration
- Ruggedized Construction
- Frequency Range:
  Model 292-D 392-408 cps
  Model 292-E 380-440 cps

May be mounted independently of the sensing mechanism. Temperature cycled inductors provide high stability and repeatability under extreme conditions.

If you are faced with a development, design or production problem in the fields of automation, electronics or data reduction equipment, contact our engineers. They will be happy to aid you.

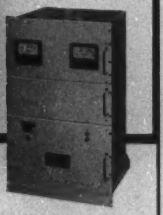
CONSOLIDATED AVIONICS CORPORATION
A SUBSIDIARY OF
CONSOLIDATED DIESEL ELECTRIC CORPORATION
800 Shames Drive, Westbury, New York
EDgewood 4-8400

▲ Circle 32 on the card.

For Missile Testing and general use
50 to 300 Amps

CHRISTIE
SILICON
POWER RECTIFIERS

Available in Industrial and Military types. Military type meets specs MIL-E-4970 and MIL-I-6181. Other stationary and mobile styles available up to 1500 Amps.



Write for Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.
Dept. EE, 3410 W. 67th St., Los Angeles 43
Over a Quarter Century of Rectifier Manufacturing

▲ Circle 33 on the card.

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MARCH 1958
APRIL

ELECTRICAL ENGINEERING

Please mail (parcel post) to:
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

Print your name and address upon mailing wrapper. Twenty-five cent refund plus postage will be paid for copies returned.

New Products

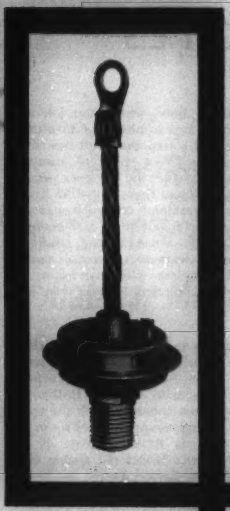
(Continued from page 36A)

Power Megaphone Runs on Flashlight Batteries. A self-contained, lightweight power megaphone has been announced by Motorola. Powered by ordinary flashlight batteries, the fully transistorized "Power Voice" megaphone has an effective range up to three-quarters of a mile. The sturdy water-resistant construction of the unit makes it ideal in all weather for activities requiring extra voice power. Designed for highest audio output per pound, the unit weighs 8 pounds, yet provides a full 15 watts amplification of thunder-like power. Because of the low drain characteristics of the 6-transistor amplifier, the flashlight cells supplying primary power last for months, depending on frequency and extent of usage. The "Power Voice" megaphone is available at Motorola Communications and Electronics, Inc., sales offices throughout the country. For more information, write to Motorola, Inc., Communications and Industrial Electronics Division, Technical Information Center, 4501 W. Augusta Blvd., Chicago 51, Ill. *Circle 218 on the card.*

Dual Transistorized Power Supply. A tubeless dual transistorized voltage regulated power supply featuring excellent regulation, low ripple content, fast recovery time, good stability, and low output impedance is the Model *2SC-100-0.2* which delivers two completed isolated outputs, each 0-100 volts, 0-0.2 ampere. Regulation for line or load is less than 0.03% or 0.003 volts, whichever is greater. Ripple is less than 1 millivolt rms. Recovery time is less than 50 microseconds. Stability for 8 hours is less than 0.03% or 0.003 volts, whichever is greater. Output impedance is less than 0.1 ohm. Contact Kepco Laboratories, Inc., 131-38 Sanford Ave., Flushing 55, N. Y., for further information. *Circle 219 on the card.*

Unique Metal Insulation. The introduction of a new type of prefabricated thermal insulation changes all previous concepts. It is an all-metal reflective insulation utilizing an entirely different approach to the problem of controlling operating temperatures, and of minimizing heat losses. This unique product is sold under the trade name, Mirror Insulation. Literally done with mirrors, this insulation utilizes a reflective principle which has long been employed in the well-known Thermos bottle. The insulation can be constructed to handle industrial temperatures in the range of —400F to +2,000F. Mirror Insulation is engineered, manufactured, and distributed by Mirror Insulation Company (Inc.), 201 S. Main St., Lambertville, N. Y. *Circle 220 on the card.*

Color Coding. A low-cost machine for color stripping vinyl insulated wires is now being offered by ORganic DEvelopment COrporation, Spectra-Strip Division, 10052 Larson Ave., Garden Grove, Calif. For further details contact John Ford, Sales Manager. *Circle 221 on the card.*



Now! A bigger choice of G-E high current silicon rectifiers

MORE THAN 290 TYPES LET YOU MATCH RECTIFIER TO JOB MORE ACCURATELY AT LESS COST

Start With These Basic Units

	Type 4JA60 series 50 to 400 (increments of 50 v)	Type 4JA62 series 50 to 400 (increments of 50 v)
Maximum Peak Inverse Voltage		
Operating Junction Temp.	200°C	150°C
Max. Ave. Forward Current Per Cell		
Stud temp.		
@ 80°C		64 amps
@ 110°C	92	41 amps
@ 130°C	76	24 amps
@ 180°C	29	
Max. Allowable 1-Cycle Surge Current	900	900 amps
Typical Forward Voltage Drop		
@ 70 amps	1.0	1.0 volts

Then Pick the Variations You Need

- ☐ **Positive polarity (stud is cathode)**
- ☐ **Negative polarity (stud is anode)**
- ☐ **Flexible braided lead**
- ☐ **Top stud**
- ☐ **Without fin**
- ☐ **With unmounted single fin**
- ☐ **Hundreds of stacked combinations for almost every circuit requirement. Up to 12 fins with inputs as high as 840 volts.**

For complete application and performance data call your G-E Semiconductor Representative, or write General Electric Company, Semiconductor Products Department, Section S18558, Electronics Park, Syracuse, New York.

GENERAL ELECTRIC

For more information circle 34 on reader service card.

CONTINENTAL FOR THE COMPLETE LINE OF INSULATED POWER CABLE

VOLTAGES: 600 TO 15,000
SIZES: 14 AWG TO 2,000,000 CM
INCLUSIVE

With a complete range of voltages and sizes, Continental Wire offers POWER CABLE in types V . . . AIA . . . AVA . . . AVB . . . *SILICONE RUBBER* . . . TEFLON TAPE . . . and VARNISHED GLASS TAPE for extremely high temperatures. For power cable with excellent current carrying capacities, resistance to oil, grease, corrosive vapors, moisture, as well as high temperatures—call CONTINENTAL, Wallingford.

continental wire corporation

WALLINGFORD, CONN. / YORK, PENNA.
Circle 35 on reader service card.

INDUSTRIAL NOTES

Eagle Electric Expands. The manufacturers of the OK Fuse Plugs and over 1,500 other electrical wiring devices and specialties, has further enlarged its facilities. Eagle Electric, 23-10 Bridge Plaza S., Long Island City 1, N. Y., has just purchased the entire assets of the Matol Corp., Tilton, N. H., for the manufacture of metal socket shells and caps. They also acquired the automatic screw machine department of the Chase Brass & Copper Co., Waterbury Manufacturing Co. Division, Waterbury, Conn., and the Bottom Turn Knob Socket Division, Alcor Manufacturing Co., Chicago, Ill.

Reinforced Plastic TV Cabinet. A reinforced plastic television cabinet made by the high-strength preform method of molding is featured in its 1958 line of portable television models by Packard-Bell Electronics Corp., Los Angeles, Calif. The plastic material, composed of resin-bonded glass fiber, was selected because of its strength, ruggedness, light weight, lasting color, and resistance to scuffing and staining, factors especially important to portability. In addition, the material's acoustical properties are rated good, and it is a nonconductor of electricity. The cabinet is supplied by Minnesota Mining and Manufacturing Co., Gardena, Calif. For further information contact Minnesota Mining and Manufacturing Co., 900 Bush St., St. Paul 6, Minn.

Pilot Plant Acquisition. A computer-controlled pilot plant designed to save scientific manpower and speed development of new refining processes will be acquired by Esso Research and Engineering Company. The automatic miniature plant is being built by the Systems Division of Consolidated Electrodynamics Corporation, 300 N. Sierra Madre Villa, Pasadena, Calif., in co-operation with the oil research firm. It will be compact enough to fit into an average-sized 10-foot by 12-foot office.

Shure to Make Dynetic Cartridge. A precision-engineered stereophonic phonograph cartridge using a moving-magnet principle, will be placed on the market by Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill., as soon as stereo records are available to the public. The principle of a moving magnet in a stationary coil, providing high fidelity response with low needle-tip mass and extreme compliance, was introduced in the studio dynetic phono reproducer. The studio dynetic operates with a stable tracking force of one to two grams. The stereo dynetic cartridge can be used in any standard phonograph arm and probably will operate at a tracking force of from three to four grams.

Prefabrication and Helicopters. Putting up a building in a relatively inaccessible area is getting easier, thanks to the combination of prefabrication and helicopters. The Pacific Gas and Electric Company, with a line construction job in a mountainous area southeast of Livermore, Calif., needed a tool shed and flew it in. The 9-foot by 9-foot structure, complete with floor and windows, is a stock product of the Porta House Company, 6767 Broadway Terrace, Oakland, Calif. Porta Houses are made of 3-foot panels and come in all sizes. The Porta House, built of weatherproof marine plywood panels, packaged complete with bolt-holes and hardware, was erected by two men in a short time.

Bendix Opens Analog Computing Facility. Engineering and scientific capabilities of Pacific Division, Bendix Aviation Corporation, 11600 Sherman Way, N. Hollywood, Calif., have been enhanced with the opening of an analog computing facility in the Systems Analysis Branch. Heart of the facility is a REAC Model *400* analog computer built for Bendix-Pacific by Reeves Instrument Corporation, New York. The computing facility and its staff will assist all engineering personnel in the more rapid and efficient solutions of engineering and scientific problems such as missile and aircraft guidance, control and stability, and analysis of electromechanical, electronic, and hydraulic systems.

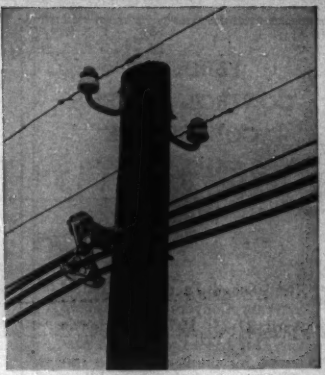
Research and Development Facility Set Up. A new research and development facility has been set up in the Boston, Mass., area by Harvey-Wells Electronics, Inc., Southbridge, Mass. The division will specialize in the development of commercial products for the Manufacturing Division and will also handle a certain amount of Government and private development work. Inquiries regarding contract services and commercial products are invited. For further data, write to Harvey-Wells Electronics, Inc., Research and Development Division, 5168 Washington St., West Roxbury, Mass.

Electronic Brain for Lighting Dynamics. Lighting Dynamics, formerly Ruby Lighting, a new subsidiary of Ekco Products Co., is computing the coefficients of utilization for its fluorescent fixtures on an electronic magic brain computer. The results are accurate to five decimal places. This information is for the company's new catalog, now in production. All coefficients are based on the interflectance method. The catalog may be reserved by writing to Lighting Dynamics, Inc., 802 W. Whittier Blvd., Whittier, Calif., or Lighting Dynamics (Texas) Inc., 8700 Ambassador Row, Dallas, Texas.

New Research Firm. The firm of William M. Brobeck & Associates, 1920 Park Blvd., Oakland 6, Calif., has been organized to provide engineering research, design, product development, and process improvement services in the electronic and mechanical fields.

(Continued on page 46A)

New Roeclamp* Cable System Costs 60% Less than Self-Supporting Cables, Minimizes Tree Problems, Installs with Ease, Looks Better!



New Roebling Aerial Spaced System with ROECLAMP requires only one foot of clearance through trees! Note improved, compact appearance. No crossarms are needed.

Designed for 5kv systems (2400/4160Y and 4800 v delta) and 8kv systems (4800/8320Y and 7200 v delta), the Roebling Aerial Spaced System actually costs 60% less than conventional self-supporting cables. It provides a neat, compact appearance, improved voltage regulation, higher current-carrying capacity, and positive phase identification.

Up to three conductors can be carried by ROECLAMPS, which are suspended from a strong messenger. The messenger also provides protection against lightning and falling limbs.

Aluminum conductors come in 17 standard sizes and strand constructions, and are made with a greater number of finer strands for extra flexibility. Standard insulation is extruded ROEPLASTIC® P-11R7 (other extruded insulations available). ROECLAMPS come complete with grommets to fit cables and messenger you order.

Ask your Roebling representative to show you the remarkable new ROECLAMP. He'll tell you more, too, about the unusual savings and improvements you can effect with the ROECLAMP System, or write Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

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Roeclamp has unit construction... installs in seconds—without tools!

One motion and ROECLAMP is on messenger and ready to receive conductors. Phase changes and repairs do not necessitate removal of clamp. ROECLAMP comes complete with grommets to fit messenger and conductors you order.

Note how easily conductors drop into place. Installation is measured in seconds, even with "boxing gloves" on. ROECLAMP is Plexiglas†, tests to over 1000-lb. breaking strength, offers outstanding weather resistance, best possible electrical properties.

35 ROECLAMPS are required every 1000 feet. Installation is completed by hand-tightening of nut. Not even a screw driver is required!

*Pat. pending
†Reg. T. M.—Rohm & Haas Co.

For more information circle 36 on reader service card.

FEEDBACK CONTROL SYSTEMS CONFERENCE

The second Feedback Control Systems Conference was held April 21-23, 1954 at Atlantic City, N. J. The papers, as prepared by their respective authors are included in publication S-63. The technical papers and scheduled demonstrations covered the following fields and subjects:

Industrial regulators
Tracer machine tools
Process control
Nucleonics
Aircraft engines
Flight path control
Fire control
Platform stabilization
Flight simulators
Computers
Test equipment
Magnetic Amplifiers
Potentiometers
Gears and dampers

The preceding list indicates a wide range of applications of feedback control as well as the diversity of components.

This 158-page publication, S-63, is available at the price of $3.50 to members and nonmembers from the Order Department

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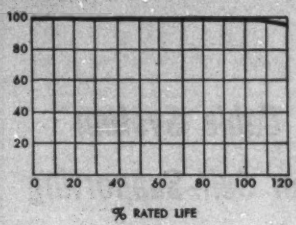

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Circle 37 on the card.

Industrial Notes

(Continued from page 42A)

Electro-less Copper Plating. An electroless process of plating high conductivity copper on ceramic directly out of solution is proving both economical, because of mass production methods, and more efficient electrically because of the close chemical bond it effects between copper and ceramic. The copper is plated uniformly on irregular or complex surfaces. Referred to as the Kemetal process, it is used in the manufacture of disc capacitors and feed-throughs. Further information may be obtained from the manufacturer, Radio Industries, Inc., 5225 N. Ravenswood Ave., Chicago 40, Ill.

Alcoa Die Casting Alloy. An aluminum die casting alloy, with built-in structural and bearing strength, has been made available. Alloy *X385* will find use where it is advantageous to provide integral bearing surfaces instead of cast-in or specially assembled bearings or bushings. The new alloy will withstand loads of 1,500 psi. Further information may be obtained by writing Aluminum Company of America, Room 731, Alcoa Building, Pittsburgh 19, Pa., or by contacting the nearest Alcoa sales office.

Scintillation Crystals. Thallium-activated sodium-iodide crystals, grown in ingots 5 by 4 inches long plus a 90° conical end, can be supplied in any sizes and configurations derivable from this shape. Cylinders, cylinders with truncated conical ends, and cylinders with re-entrant end wells can be supplied either unmounted, enclosed in standard mounts, or specially mounted to individual requirements. In

the production of these crystals, special attention has been given to the attainment of the highest possible optical clarity for the minimum absorption of visible and ultraviolet light to result in maximum effective conversion efficiency and superior resolution; and uniform distribution of thallium to insure response to gamma rays uniformly throughout the crystal volume. Transmission characteristics of each individual crystal are tested and recorded in an automatic monochromator. For further information contact Levinthal Electronic Products, Inc., Nuclear Division, Stanford Industrial Park, Palo Alto, Calif.

TRADE LITERATURE

Fireless Steam Cleaner Bulletin. A free 2-page bulletin describing a fireless steam cleaner, is being offered by Kelite Corporation, 81 Industrial Rd., Berkeley Heights, N. J. The bulletin describes how the Kelite fireless, which is less expensive than comparable direct-fired steam cleaners, uses live steam from an existing steam supply, thus providing the efficient cleaning power of high-volume steam cleaners. Interested readers should ask for Bulletin *P-7578.*

"Plug-In" Servo Systems. An offer of file folder and specification sheets on the Micromation products is now available from Waldorf Instrument Company. Included are plug-in servo repeater systems, subminiature servo amplifiers, and a discussion of micromation. For a copy of this brochure, write to Waldorf Instrument Company, Huntington Station, L.I., N. Y.

Conversion Factors Wall Chart. A reference table for engineers and other executives in Wall Chart form has been published by Precision Equipment Co. This conversion chart is very useful for engineers, shop men, and other executives. Included are common conversions such as inches to centimeters or watts to horsepower as well as many conversions that are difficult to locate in reference manuals. For a free wall chart of conversion factors, write Precision Equipment Co., 4411E Ravenswood Ave., Chicago 40, Ill.

Digitometry Bulletin. "Digitometry, A Concept of Digital Control and Indication" is the title of a 4-page technical bulletin released by and available from Anatran Corporation, 45 W. Union St., Pasadena, Calif. It describes five new components for use as digital actuators and feedback devices in servo and instrumentation systems.

Precision Finishing Catalog. A 24-page, 4-color catalog on precision metal finishing by mechanical barrel-finishing methods is now available from Roto-Finish Co., 3700 Milham Rd., Kalamazoo, Mich., P.O. Box 988. The publication sets forth a clear explanation of mechanical finishing processes. The story of how roto-finishing is applied to the grinding, deburring, descaling, polishing, and coloring of metal parts contains special information for process engineers. It answers some of the basic questions to the problem of achieving large-quantity production runs while maintaining exact tolerances and uniformity of finish.

Large Induction Motor Bulletiu. A 16-page Bulletin *1950*, on Large Induction Motors has been published by the Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. This bulletin presents detailed information on a full line of motors in ratings from 150 to 1,250 hp.

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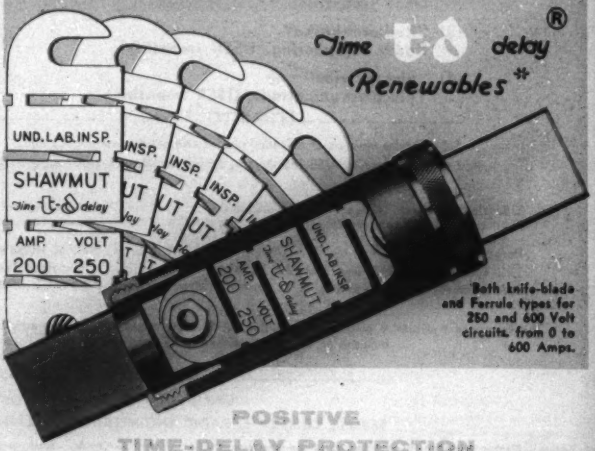

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